(19)日本国特許庁（ＪＰ）　(12)特　許　公　報（Ｂ２）　(11)特許番号
特許第3374659号
(P3374659)

(45)発行日　平成15年２月10日(2003.2.10)　(24)登録日　平成14年11月29日(2002.11.29)

(51)Int.Cl.⁷	識別記号	ＦＩ	
Ｃ２１Ｄ　8/10		Ｃ２１Ｄ　8/10	Ｃ
8/02		8/02	Ｃ
Ｃ２２Ｃ　38/00	３０１	Ｃ２２Ｃ　38/00	３０１Ｚ
38/18		38/18	
38/58		38/58	

請求項の数５（全 15 頁）

(21)出願番号　特願平8－146029
(22)出願日　平成８年６月７日(1996.6.7)
(65)公開番号　特開平9－104921
(43)公開日　平成９年４月22日(1997.4.22)
審査請求日　平成12年１月26日(2000.1.26)
(31)優先権主張番号　特願平7－143207
(32)優先日　平成７年６月９日(1995.6.9)
(33)優先権主張国　日本（ＪＰ）
(31)優先権主張番号　特願平7－201172
(32)優先日　平成７年８月７日(1995.8.7)
(33)優先権主張国　日本（ＪＰ）

(73)特許権者　000004123
日本鋼管株式会社
東京都千代田区丸の内一丁目１番２号
(72)発明者　豊田　俊介
東京都千代田区丸の内一丁目１番２号
日本鋼管株式会社内
(72)発明者　三辻　晴夫
東京都千代田区丸の内一丁目１番２号
日本鋼管株式会社内
(72)発明者　大村　雅紀
東京都千代田区丸の内一丁目１番２号
日本鋼管株式会社内
(74)代理人　100058479
弁理士　鈴江　武彦　（外４名）

審査官　諸岡　健一

最終頁に続く

(54)【発明の名称】　超高張力電縫鋼管およびその製造方法

(57)【特許請求の範囲】

【請求項１】　重量％で、Ｃ：０．１０～０．１９％、Ｓｉ：０．０１～０．５％、Ｍｎ：０．８～２．２％、Ａｌ：０．０１～０．０６％、Ｃｒ：０．０５～０．６％、Ｐ：０．０２％以下、Ｓ：０．００３％以下、Ｎ：０．００５％以下、残部Ｆｅ及び不可避的不純物からなる鋼スラブに対し、前記鋼のＡｒ$_3$変態点の温度をＴＡｒ$_3$としたとき、仕上げ温度Ｔｆが（ＴＡｒ$_3$＋３０）～（ＴＡｒ$_3$＋１００）℃の温度範囲になるように仕上げ温度Ｔｆを制御して熱間圧延を施し、その熱間圧延の際に、Ｔｆ～（Ｔｆ＋３０）℃の温度範囲で３０％以上＊の圧下率を与え、熱間圧延後直ちに６０～２００℃／ｓｅｃの冷却速度で１５０～２５０℃の温度範囲の温度Ｔｃまで冷却した後、１５０℃以上Ｔｃ以下の温度範囲に２秒以上滞留させ、１５０℃未満の温度で巻取って熱延鋼板とし、この熱延鋼板を以下の（１）式を満たす幅絞り率Ｑで造管することを特徴とする超高張力電縫鋼管の製造方法。

$$1000 \leqq Q/(t/D)^2 \leqq 3000 \cdots\cdots (1)$$

ただし、ｔ(mm)：鋼板の板厚、Ｄ(mm)：電縫鋼管の外径、Ｑ（％）は幅絞り率で、以下の式（２）で定義される。

Ｑ＝［｛鋼板の幅－π（Ｄ－ｔ）｝／π（Ｄ－ｔ）］×100 ……（２）

【請求項２】　さらに、重量％で、Ｎｂ：０．００５～０．０３％、Ｖ：０．００５～０．０３％のうち少なくとも１種を含有することを特徴とする請求項１に記載の超高張力電縫鋼管の製造方法。

【請求項３】　さらに、重量％で、Ｂ：０．０００５～０．００３０％を含有することを特徴とする請求項１ま

たは請求項２に記載の超高張力電縫鋼管の製造方法。

【請求項４】　さらに、重量%で、Ｃｕ：０．０５～０．５０%を含有することを特徴とする請求項１ないし請求項３のいずれか１項に記載の超高張力電縫鋼管の製造方法。

【請求項５】　さらに、重量%で、Ｎｉ：０．３%以下であることを特徴とする請求項４に記載の超高張力電縫鋼管の製造方法。

【発明の詳細な説明】

【０００１】

【発明が属する技術分野】本発明は、ドアインパクトビームなどの自動車用部材、さらには機械構造用部材、土木建築用部材に用いられる超高張力電縫鋼管およびその製造方法に関する。

【０００２】

【従来の技術】自動車などの車両ドア内部には、安全性の観点からドアインパクトビームと呼ばれる補強材が設けられている。従来のドアインパクトビームには、高張力冷延鋼板のプレス成型品が用いられることが多かったが、近年、軽量化のために、引張強度が９８０Ｎ／ｍｍ^2 以上の著しく強度の高い高張力電縫鋼管が採用されるようになってきている。

【０００３】これまで、超高張力鋼管に関しては、特開平1-205032号、特開平4-131327号、特開平4-187319号、特開平6-57375 号、特開平6-88129 号、特開平6-179913号の各公報に開示されている、所定の化学成分を有する鋼を引張強度９８０Ｎ／ｍｍ^2 以上の高張力鋼板とした後、電縫溶接し高強度電縫鋼管を得る方法が提案されている。

【０００４】また、特開平3-122219号、特開平4-63227号の各公報に開示されている、所定の化学成分を有する鋼管に焼入れ処理を行い、引張強度１１８０Ｎ／ｍｍ^2 以上の高張力電縫鋼管を得る方法が提案されている。

【０００５】

【解決しようとする課題】上記特開平1-205032号、特開平4-131327号、特開平4-187319号、特開平6-57375 号、特開平6-88129 号、特開平6-179913号の各公報などに示された方法は、造管に伴い残留歪みが存在するため、その実用に際しては水素遅れ割れに対する配慮が必要である。

【０００６】しかし、これまでに示された方法では、水素遅れ割れに対する配慮がなされていないか、あるいは＊なされていても十分でなく、したがって超高張力鋼管の需要拡大が制限されている。

【０００７】一方、特開平3-122219号、特開平4-63227号の各公報に示された方法は、引張の残留歪みはないものの、その使用中に腐食が進むと管体強度が低下することが問題である。

【０００８】本発明はかかる事情に鑑みてなされたものであって、引張強度が高く、耐水素遅れ割れ特性に優れた、またはこれに加えて耐食性にも優れた超高張力電縫鋼管およびその製造方法を提供することを目的とする。

【０００９】

【課題を解決するための手段】本発明者らは、前記目的を達成するために多くの実験的検討を行った結果、鋼成分の調整、および鋼板の熱処理条件および造管条件を適正化して組織を調整することにより耐水素遅れ割れ特性に優れた、またはこれに加えて耐食性にも優れた超高張力電縫鋼管を得ることが可能となるという知見を得た。

【００１０】本発明はこのような知見に基づいてなされたものであり、

【００１１】重量%で、Ｃ：０．１０～０．１９%、Ｓｉ：０．０１～０．５%、Ｍｎ：０．８～２．２%、Ａｌ：０．０１～０．０６%、Ｃｒ：０．０５～０．６%、、Ｐ：０．０２%以下、Ｓ：０．００３%以下、Ｎ：０．００５%以下、残部Ｆｅ及び不可避的不純物からなる鋼スラブに対し、前記鋼のAr_3変態点の温度をTAr_3としたとき、仕上げ温度Ｔｆが（TAr_3＋３０）～（TAr_3＋１００）℃の温度範囲になるように仕上げ温度Ｔｆを制御して熱間圧延を施し、その熱間圧延の際に、Ｔｆ～（Ｔｆ＋３０）℃の温度範囲で３０%以上の圧下率を与え、熱間圧延後直ちに６０～２００℃／ｓｅｃの冷却速度で１５０～２５０℃の温度範囲の温度Ｔｃまで冷却した後、１５０℃以上Ｔｃ以下の温度範囲に２秒以上滞留させ、１５０℃未満の温度で巻取って熱延鋼板とし、この熱延鋼板を以下の（１）式を満たす幅絞り率Ｑで造管することを特徴とする超高張力電縫鋼管の製造方法を提供する。

【００１２】

$$1000 \leq Q/(t/D)^2 \leq 3000 \quad \cdots\cdots (1)$$

ただし、ｔ(mm)：鋼板の板厚、Ｄ(mm)：電縫鋼管の外径、Ｑ（%）は幅絞り率で、以下の式（２）で定義される。

$$Q = [\{鋼板の幅 - \pi(D-t)\}/\pi(D-t)] \times 100 \quad \cdots\cdots (2)$$

【００１３】

【発明の実施の形態】本発明の超高張力電縫鋼管は、鋼の成分組成および組織を制御することによりはじめて達成されるものである。本発明の第１実施形態および第２実施形態はそのために特定の成分組成の鋼板の熱処理条件および造管条件等を規定するものであり、第３実施形態は鋼の成分組成および組織自体を規定するものである。

【００１４】以下、各実施形態についてて詳細に説明する。

（１）第１実施形態

（化学組成）引張強度が９８０Ｎ／ｍｍ^2 以上で、しかも優れた耐水素遅れ割れ特性を得るために、Ｃ：０．１０～０．１９%、Ｓｉ：０．０１～０．５%、Ｍｎ：

０．８～２．２％、Ａｌ：０．０１～０．０６％、Ｎｂ：０．００５～０．０３％、Ｂ：０．０００５～０．００３０％を含み、さらにＰ：０．０２％以下、Ｓ：０．００３％以下、Ｎ：０．００５％以下、Ｔｉ：０．０１５％以下に制限した組成に規定する。また、Ｃｕ：０．０５～０．５０％が選択成分として添加される。その場合に、Ｎｉを添加することがあるが、Ｎｉ：０．１０％以下とする。

【００１５】以下、各元素の限定理由について説明する。

Ｃ：　Ｃは所望のマルテンサイトを生成させ、目標とする強度を確保するために必須な元素である。しかし、含有量が０．１０％未満であると目標とする９８０Ｎ／ｍｍ² 以上の強度が得られず、一方、含有量が０．１９％を超えると、引張強度が高くなりすぎるか、あるいは焼戻し時に析出する炭化物サイズが大きくなり、いずれにせよ耐水素遅れ割れ特性が劣化する。したがってＣの含有量を０．１０～０．１９％とする。

【００１６】Ｓｉ：　Ｓｉは電縫溶接部の健全性を確保するために添加され、その効果はその含有量が０．０１～０．５％で発揮されるため、Ｓｉの含有量を０．０１～０．５％とする。

【００１７】Ｍｎ：　Ｍｎはオーステナイトの焼入れ性を向上させて所望のマルテンサイトを生成させ、目標とする強度を確保するために必須な元素である。しかし、含有量が０．８％未満であると目標とする９８０Ｎ／ｍｍ² 以上の強度が得られず、一方、含有量が２．２％を超えると耐水素遅れ割れ特性が劣化する。したがって、Ｍｎの含有量を０．８～２．２％とする。

【００１８】Ａｌ：　Ａｌは脱酸元素として添加され、また鋼中の不純物として存在するＮをＡｌＮとして固定し、耐水素遅れ割れ特性を向上させる。しかし、その添加効果は０．０１％未満では少なく、一方０．０６％を超えると介在物が増加し、耐水素遅れ割れ特性が劣化する。したがってＡｌの含有量を０．０１～０．０６％とする。

【００１９】Ｎｂ：　Ｎｂは連続焼鈍炉における加熱時のオーステナイト粒成長を抑制し、マルテンサイト組織を微細化し、耐水素遅れ割れ特性を向上させる元素である。その添加効果は０．００５％以上で認められ、一方、０．０２％を超えて添加しても添加効果が飽和する。したがって、Ｎｂの含有量を０．００５～０．０２％とする。

【００２０】Ｂ：　Ｂは所望のマルテンサイトを生成させ、目標とする強度を確保するために必要な元素である。しかし、添加量が０．０００５％未満であると目標とする９８０Ｎ／ｍｍ² 以上の強度が得られず、一方、添加量が０．００３０％を超えても添加効果が飽和する。したがって、Ｂの含有量を０．０００５～０．００３０％とする。

【００２１】Ｐ：　Ｐは耐遅れ破壊特性を劣化させるため、０．０２％以下に規制することが必要である。

Ｓ：　Ｓは介在物として存在し、耐水素遅れ割れ特性を劣化させるため、０．００３％以下に規制することが必要である。

【００２２】Ｎ：　Ｎが０．００５％を超えて含まれると耐水素遅れ割れ特性が低下するため、０．００５％以下に規制することが必要がある。

Ｔｉ：　Ｔｉは粗大な窒化物として析出すると、耐水素遅れ割れ特性を低下させるので、添加しないことが望ましい。しかし、固溶ＮをＴｉＮとして固定し、Ｂの焼入れ性を確保するためにやむなく添加する場合には、その添加量を０．０１５％以下とする必要がある。

【００２３】Ｃｕ：　Ｃｕは鋼管の腐食の進行を抑制し、かつ鋼管中への水素の侵入を抑制し、耐水素遅れ割れ特性を向上させる元素である。その添加効果は０．０５％以上で認められ、一方０．５０％を超えて添加しても添加効果が飽和する。したがって、Ｃｕを添加する場合にはその含有量を０．０５～０．５０％とする。

【００２４】図１にＣｕ添加量と割れ発生限界付加歪み（Δε）の変化量との関係を示す。この図から、Ｃｕ添加によって割れ発生限界付加歪み（Δε）が増大し、水素遅れ割れが抑制されることが理解される。

【００２５】Ｎｉ：　Ｎｉは鋳造偏析によって局所的な腐食を助長し、耐水素遅れ割れ特性を低下させるため添加しないことが望ましい。しかし、熱延時のＣｕ疵を回避するためにやむなく添加する場合には、含有量を耐水素遅れ割れ特性の低下が著しくない０．１０％以下とする。

【００２６】図２にＮｉ添加量と割れ発生限界付加歪み（Δε）の変化量との関係を示す。この図から、Ｎｉ添加によって割れ発生限界付加歪み（Δε）が減少し、水素遅れ割れが助長されることが理解される。

【００２７】（製造条件）上記化学組成の鋼スラブを１１５０～１３００℃で均熱した後、このスラブに対してＡｒ$_3$ 点以上を仕上温度とする熱間圧延を施し、５００～６５０℃で巻取って熱延鋼帯とし、この熱延鋼板を酸洗冷圧後、連続焼鈍炉で８００～９００℃に均熱加熱後急冷し、さらに１５０～２５０℃で焼戻し処理を行い、得られた鋼板を以下の（１）式を満たす幅絞り率Ｑで造管し、８０～１００％焼戻しマルテンサイト＋残部フェライト組織とする。

【００２８】Ａ．熱間圧延条件

ａ．スラブ加熱温度

スラブ加熱温度はＮｂを固溶させるために１１５０℃以上である必要がある。スラブ加熱温度が１１５０℃に満たないと、連続焼鈍炉における加熱時にＮｂが十分なsolute drug 効果を発揮しないため、マルテンサイト組織が微細とはならず、Ｎｂ添加による耐水素遅れ割れ特性の向上効果が得られない。一方、操業性の観点からスラ

ブ加熱温度の上限を1300℃とする。

【0029】b．仕上圧延温度

仕上圧延温度はAr_3点以上である必要がある。仕上圧延温度がAr_3点以下であると、フェライト変態部でのNb炭窒化物の歪誘起析出により、連続焼鈍炉における加熱時にNbが十分なsolute drug 効果を発揮しないため、マルテンサイト組織が微細とはならず、Nb添加による耐水素遅れ割れ特性の向上効果が得られない。

【0030】c．巻取温度

巻取温度は500～650℃とする。巻取温度が650℃を超えるとNb炭化物が粗大化し、連続焼鈍炉における加熱時に再固溶せず、十分なsolute drug 効果を発揮しないため、マルテンサイト組織が微細とはならず、Nb添加による耐水素遅れ割れ特性の向上効果が得られない。一方、巻取温度が500℃未満であると熱延鋼帯が硬質化し、操業上問題となる。

【0031】B．連続焼鈍炉での熱処理条件

a．加熱温度

連続焼鈍炉における加熱温度は800～900℃とする。800℃未満では急冷後に十分な量のマルテンサイト量が得られず、目標とする強度が得られない。一方、＊900℃を越えると加熱時のオーステナイト粒粗大化により、微細なマルテンサイト組織が得られず、耐水素遅れ割れ特性が低下する。

【0032】b．焼戻し熱処理条件

加熱－急冷により得られた80～100%マルテンサイト＋残部フェライト組織とされた鋼帯は、150～250℃の温度範囲で焼戻し処理を行う。焼戻し温度150℃未満ではマルテンサイト変態歪が残存し、造管後の耐水素割れ性が低下する。一方、焼戻し温度が250℃を超えると、焼戻しに伴い析出するセメンタイト相が粗大となり、耐遅れ破壊特性が低下する。

【0033】C．造管条件

電縫溶接－サイジングの造管工程における幅絞りは、鋼管の耐水素遅れ割れ特性を良好にせしめるための重要な要件であり、このためには幅絞り率Qを（1）式で示される範囲内に制御した上で造管を行う。

【0034】

$$1000 \leq Q/(t/D)^2 \leq 3000 \cdots\cdots (1)$$

ただし、t(mm)：鋼板の板厚、D(mm)：電縫鋼管の外径、Q（%）は幅絞り率で、以下の式（2）で定義される。

$$Q = [\{鋼板の幅 - \pi(D-t)\}/\pi(D-t)] \times 100 \cdots\cdots (2)$$

図3に$Q/(t/D)^2$と水素遅れ割れ発生限界付加歪み$\Delta\varepsilon_c$の関係を示す。本発明者らは造管条件と耐水素遅れ割れ特性に関する多くの実験的検討を行った結果、図3に示すように、鋼管の水素遅れ割れ発生限界付加歪みは幅絞り率Qが$1000(t/D)^2$～$3000(t/D)^2$の間でピークを持ち、幅絞り率をこの範囲に制御することで優れた耐水素遅れ割れ特性を有する鋼管が得られることを見出した。この適正幅絞り率は製品(板厚/外径)比により異なり、優れた耐水素遅れ割れ特性を有する鋼管を得るためには(板厚/外径)比ごとに異なる幅絞り率をとる必要がある。

【0035】鋼管の耐水素遅れ割れ特性が、幅絞り率$Q=1000(t/D)^2$～$3000(t/D)^2$の間でピークを持つ理由は次のように考えられる。すなわち、幅絞り率が$1000(t/D)^2$に満たない場合には、※鋼管の最大残留歪みが増大し、鋼管の耐水素遅れ割れ特性が劣化し、逆に、幅絞り率が$3000(t/D)^2$を越える場合には、造管にともない造管圧延集合組織が形成され、鋼管の耐水素遅れ割れ感受性が高まり鋼管の耐水素遅れ割れ特性が劣化する。

【0036】なお、水素遅れ割れ発生限界付加歪$\Delta\varepsilon_c$は、電縫鋼管より幅20mmのC－リング試験片を切出し、切出し前の外径までボルト締めを行い鋼管の残留歪み相当の歪みを加えた後、さらに以下の（3）式で計算される付加歪み（$\Delta\varepsilon$）を加えて0．1N塩酸中に200時間浸漬し割れ発生有無を調べた際における、割れが発生する限界の付加歪みを指す。この値を耐水素遅れ割れ特性の指標とする。すなわち、この値が高いほど耐水素遅れ割れ特性にとっては好ましい。

【0037】

$$\Delta\varepsilon = (4 \cdot 10^6 \cdot t \cdot \delta)/(\pi \cdot D \cdot (D-t)) \cdots\cdots (3)$$

ここで、tは板厚、Dは切出し前の鋼管の外径、δはD－（付加歪み付加後の外径）である。

【0038】以上のような方法によって80～100%焼戻しマルテンサイト＋残部フェライト組織を形成することにより、耐水素遅れ割れ特性に優れた引張強度980N/mm^2以上の電縫鋼管が製造される。

【0039】（2）第2実施形態

（化学組成）引張強度が980N/mm^2以上で、しかも優れた耐水素遅れ割れ特性を得るために、重量%で、C：0．10～0．19%、Si：0．01～0．5%、Mn：0．8～2．2%、Al：0．01～0．06%、Cr：0．05～0．6%、を含み、P：0．02%以下、S：0．003%以下、N：0．005%以下に制限した組成に規定する。また、Nb：0．005～0．03%、V：0．005～0．03%のうち少なくとも1種、B：0．0005～0．0030%、Cu：0．05～0．50%が選択成分として添加される。また、Cuを添加した場合に、Niを添加することがあるが、Ni：0．30%以下とする。

【0040】以下、各元素の限定理由について説明する。C、Si、Mn、Alの限定理由は上記第1実施形態と同様である。

Cr： Mnとの相互作用により鋼の焼入性を上げ、目標とする強度を確保するための元素である。その含有量

が０．０５％未満であるとその効果が乏しく、一方０．６％を超えると耐水素遅れ割れ特性が劣化する。したがって、Ｃｒの含有量を０．０５〜０．６％とする。

【００４１】Ｐ、Ｓ、Ｎについては、第１実施形態と同様の理由で上記範囲に制限される。

Ｎｂ、Ｖ：　Ｎｂ，Ｖはいずれも変態前のオーステナイト粒を微細化し、変態後のマルテンサイトパケットを微細化することができるので、耐水素遅れ割れ特性の向上に好ましい元素である。しかし、それぞれ０．００５％未満ではその効果は少なく、一方０．０３％を超えて添加すると、耐水素遅れ割れ特性がかえって劣化する。したがって、Ｎｂ、Ｖの含有量をそれぞれ０．００５〜０．０３％とする。

【００４２】Ｂ：　Ｂは所望のマルテンサイトを生成させ、目標とする強度を確保するために必要に応じて添加される。しかし、添加量が０．０００５％未満であると目標とする９８０Ｎ／ｍｍ^2 以上の強度が得られず、一方添加量が０．００３０％を超えても添加効果が飽和する。したがって、Ｂの含有量を添加する場合には０．０００５〜０．００３０％とする。

【００４３】Ｃｕについいは、第１実施形態と同様の理由で添加する場合には０．０５〜０．５０％の範囲とする。Ｃｕ量を増加すると、場合によってはＣｕ疵と呼ばれる表面欠陥が発生することがあり、これはＮｉ添加によって防止することができるが、Ｎｉは耐水素遅れ割れ特性にとって有害な元素であるため、その添加量を０．３％以下に制限されることが好ましい。

【００４４】（製造条件）上記組成の鋼スラブに対し、その鋼のＡｒ$_3$ 変態点の温度をＴＡｒ$_3$ としたとき、仕上げ温度Ｔｆが（ＴＡｒ$_3$ ＋３０）〜（ＴＡｒ$_3$ ＋１００）℃の温度範囲になるように仕上げ温度Ｔｆを制御して熱間圧延を施し、その熱間圧延の際に、Ｔｆ〜（Ｔｆ＋３０）℃の温度範囲で３０％以上の圧下率を与え、熱間圧延後直ちに６０〜２００℃／ｓｅｃの冷却速度で１５０〜２５０℃の温度範囲の温度Ｔｃまで冷却した後、１５０℃以上Ｔｃ以下の温度範囲に２秒以上滞留させ、１５０℃未満の温度で巻取って熱延鋼板とし、この熱延鋼板を上記（１）式を満たす幅絞り率Ｑで造管する。

【００４５】Ａ．熱延条件

ａ．仕上温度

仕上げ温度Ｔｆは（ＴＡｒ$_3$ ＋３０）〜（ＴＡｒ$_3$ ＋１００）℃の温度範囲とする。仕上温度が（ＴＡｒ$_3$ ＋３０）℃未満であると、９８０Ｎ／ｍｍ^2 以上の強度を得るためのマルテンサイトの体積率が得られない。一方、（ＴＡｒ$_3$ ＋１００）℃を超えると、マルテンサイトパケットが粗大化し、耐水素遅れ割れ特性が低下する。

【００４６】ｂ．圧下条件

マルテンサイトを微細にし、耐水素遅れ割れ特性を良好にするためには、熱間圧延終了直前における強圧下が必要である。このため、Ｔｆ〜（Ｔｆ＋３０）℃の温度範囲で３０％以上の圧下率を与えて熱間圧延を行う。

【００４７】Ｂ．熱間圧延後の冷却条件

熱間圧延後直ちに６０〜２００℃／ｓｅｃの冷却速度で１５０〜２５０℃の温度範囲のＴｃまで急冷する。これにより９８０Ｎ／ｍｍ^2 以上の強度を得るためのマルテンサイト体積率を確保することができる。冷却速度が６０℃／ｓｅｃ未満であると所望の体積率のマルテンサイトを得ることができない。また冷却速度が２００℃／ｓｅｃを超えると操業上のトラブルを生じる。冷却停止温度については２５０℃よりも高いと所望の体積率のマルテンサイトが得られない。

【００４８】このように急冷した後は、１５０℃以上Ｔｃ以下の温度範囲に２秒以上滞留させる。これにより、硬質な焼戻しマルテンサイトが生成される。図４に急冷された鋼板を１５０〜２５０℃の温度範囲で保持したときの保持時間と水素遅れ割れ発生限界付加歪みΔεとの関係を示す。この図から、２秒以上の保持によって安定して２０００μｍに近い高い水素遅れ割れ発生限界付加歪みΔε_c が得られることがわかる。２秒未満では焼入れ歪みが残存するため、１９００μｍ以上の高いΔε_c を安定して得ることができない。

【００４９】Ｃ．巻取温度

巻取は１５０℃未満の温度で行う。この温度が１５０℃以上では、硬質な焼戻しマルテンサイト相とならず、９８０Ｎ／ｍｍ^2 以上の強度が得られない。

【００５０】Ｄ．造管条件

以上のような条件で製造された熱延鋼板を用いて超高張力電縫鋼管に造管するが、その際に、上記第１実施形態と同様、上記（１）式を満たす必要がある。

【００５１】（３）第３実施形態

（化学組成および組織）引張強度が９８０Ｎ／ｍｍ^2 以上で、しかも優れた耐水素遅れ割れ性および耐食性を得るために、Ｃ：０．１３〜０．１９％、Ｍｎ：１．０〜２．０％、Ｃｕ：０．０５〜０．５０％を含有する組成を有し、焼入れ熱処理によって得られた８０〜１００％のマルテンサイトあるいは焼戻しマルテンサイト組織とする。また、Ｎｉ、Ｍｏを添加する場合にはＮｉ：０．１％以下、Ｍｏ：０．３％以下に制限される。

【００５２】以下、各元素の限定理由について説明する。

Ｃ：　Ｃは所望のマルテンサイトを生成させ、目標とする強度を確保するために必須な元素である。しかし、含有量が０．１３％未満であると目標とする１１８０Ｎ／ｍｍ^2 以上の強度が得られず、一方、含有量が０．１９％を超えると、水素遅れ割れ、あるいは腐食による管体強度低下が助長され、耐久性が劣化する。したがってＣの含有量を０．１３〜０．１９％とする。

【００５３】Ｍｎ：　Ｍｎは所望のマルテンサイトを生成させ、目標とする強度を確保するために必須な元素である。しかし、含有量が１．０％未満であると目標とす

る１１８０Ｎ／ｍｍ²以上の強度が得られず、一方、含有量が２．０％を超える耐水素遅れ割れ、あるいは腐食特性が劣化する。したがって、Ｍｎの含有量を１．０～２．０％とする。

【００５４】Ｃｕ：　Ｃｕは鋼管の水素遅れ割れ感受性を低め、さらに腐食による管体強度低下の進行を抑制し、超高張力電縫鋼管の耐久性を向上させる元素である。その添加効果は０．０５％以上で認められ、一方０．５０％を超えて添加しても添加効果が飽和する。したがって、Ｃｕを添加する場合にはその含有量を０．０５～０．５０％とする。

【００５５】図５にＣｕ添加量と腐食試験後の残留強度率との関係を示す。この図からＣｕ添加によって残留強度率が増大し、鋼管の耐久性が増加することが理解される。なお、残留強度率は以下の式で表わすことができる。

【００５６】残留強度率（％）＝｛浸漬試験後のＴＳ（Ｎ／ｍｍ₂）／浸漬試験前のＴＳ（Ｎ／ｍｍ₂）｝×１００

ここで、

浸漬試験前のＴＳ（Ｎ／ｍｍ₂）＝浸漬試験前の引張破断荷重（Ｎ）／浸漬試験前の管断面積（ｍｍ²）

浸漬試験後のＴＳ（Ｎ／ｍｍ₂）＝浸漬試験後の引張破断荷重（Ｎ）／浸漬試験前の管断面積（ｍｍ²）

である。

【００５７】Ｎｉ：　Ｎｉは鋳造偏析によって局所的な腐食を助長し、耐水素遅れ割れ特性を低下させるため添加しないことが望ましい。しかし、熱延時のＣｕ疵を回避するためにやむなく添加する場合には、含有量を残留強度率の低下が著しくない０．１０％以下とする。

【００５８】Ｍｏ：　Ｍｏは鋳造偏析によって局所的な腐食を助長し、耐水素遅れ割れ特性を低下させるため添加しないことが望ましい。しかし、焼入れ性を確保するためにやむなく添加する場合には、含有量を残留強度率の低下が著しくない０．３０％以下とする。

【００５９】図６にＮｉ添加量と腐食試験後の残留強度との関係を示し、図７にＭｏ添加量と腐食試験後の残留強度率との関係を示す。これらの図から０．１％以下のＮｉおよび０．３％以下のＭｏの添加によって残留強度率が減少し、鋼管の耐久性が低下することが理解される。

【００６０】これら以外の元素は、鋼管の耐久性、すなわち耐水素遅れ割れ性および耐食性に対し、特に大きな影響を及ぼさず、したがってＳｉ、Ｐ、Ａｌ、Ｎｂ、Ｂ、Ｔｉ、Ｃｒなどの合金添加元素を他の目的に従って通常量適宜添加することは許容される。

【００６１】以上の組成を有する鋼を焼入れ熱処理して８０～１００％のマルテンサイトあるいは焼戻しマルテンサイト組織とする。以上のような組成および組織とすることにより、引張強度９８０Ｎ／ｍｍ²以上で、耐久性、すなわち耐水素遅れ割れ性および耐食性に優れた超高張力電縫鋼管が得られる。

【００６２】（製造条件）この第３実施形態に係る電縫鋼管を製造するに際しては、焼入れ熱処理によって８０～１００％のマルテンサイトあるいは焼戻しマルテンサイト組織が得られれば、その製造方法は限定されず、上記第１実施形態、第２実施形態の製造条件で製造することもできる。

【００６３】

【実施例】以下、本発明の実施例について説明する。
（実施例１）表１に示すＡ～Ｆの６種の鋼を溶製し、表２に示すように本発明で規定した熱延条件、連続焼鈍炉における熱処理条件、造管条件にて３１．８ｍｍφ×１．６ｍｍｔの電縫鋼管を作製した。

【００６４】これらの鋼管の引張強度、三点曲げ最大荷重を測定するとともに、耐水素遅れ割れ試験を実施した。三点曲げ試験は押し金具半径＝１５２ｍｍ、支持スパン＝６００ｍｍで行った。耐水素遅れ割れ試験は、鋼管より幅２０ｍｍのＣ－リング試験片を切出し、切出し前の外径までボルト締めを行い鋼管の残留歪み相当の歪みを加えた後、さらに上記（３）式で計算される付加歪み（Δε）を加えて０．１Ｎ塩酸中に200 時間浸漬し割れ発生有無を調べ、割れ発生限界付加歪みを耐水素遅れ割れ特性の指標とした。結果を表３に示す。

【００６５】

【表１】

鋼	化学成分 (wt%)													
	C	Si	Mn	P	S	Al	Nb	Cu	Ni	Ti	B	N		
A	0.12	0.38	1.40	0.01	0.001	0.03	0.015	tr	tr	0.011	0.0008	0.003	790	発明材
B	0.15	0.42	1.01	0.01	0.003	0.04	0.012	tr	tr	0.009	0.0012	0.003	780	
C	0.17	0.39	1.33	0.01	0.002	0.03	0.015	0.33	tr	tr	0.0018	0.002	760	
D	0.17	0.40	1.40	0.01	0.002	0.03	0.013	tr	tr	0.008	0.0012	0.003	760	
E	0.17	0.41	1.35	0.01	0.001	0.03	0.013	0.20	tr	0.010	0.0011	0.003	760	
F	0.23	0.41	1.90	0.01	0.002	0.03	tr	tr	tr	tr	tr	0.004	750	比較材

【００６６】

＊ ＊【表２】

鋼	番号	Ar3 (℃)	熱延条件			連続焼鈍炉熱処理条件		造管条件				ミクロ組織	
			加熱温度 (℃)	仕上温度 (℃)	巻取温度 (℃)	加熱温度 (℃)	焼戻し温度 (℃)	板厚 t (mm)	外径 D (mm)	絞り率 Q (%)	$Q/(t/D)^2$	マルテンサイト分率 (%)	
A	1	790	1240	830	630	890	200	1.6	31.8	4.9	1940	100	発明例
B	2	780	1230	860	620	860	190	1.6	31.8	4.9	1940	100	
C	3	760	1200	870	610	840	220	1.6	31.8	4.9	1940	100	
D	4	760	1180	850	590	850	220	1.6	31.8	4.9	1940	100	
E	5	760	1210	860	580	870	210	1.6	31.8	4.9	1940	100	
F	6	750	1250	860	610	880	220	1.6	31.8	4.9	1940	100	比較例

【００６７】

※ ※【表３】

鋼	番号	引張特性 TS (MPa)	三点曲げ特性 最大荷重 (kW)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	
A	1	１２１０	１２．１	２１４０	発明例
B	2	１３８０	１４．０	２１４０	
C	3	１４９０	１４．８	３３３０	
D	4	１５１０	１５．６	２１４０	
E	5	１５００	１５．５	３１００	
F	6	１７２０	１７．５	０	比較例

【００６８】表３から理解されるように、本発明で規定する組成を満足する鋼Ａ～Ｅは比較鋼Ｆに比べ、割れ発生限界歪みが高く、優れた耐水素遅れ割れ特性を示すことが確認された。

【００６９】（実施例２）前記した鋼Ａ～Ｅを用いて表４に示すような熱延条件、連続焼鈍炉における熱処理条件、造管条件、（板厚／外径）比を種々変化させて電縫鋼管に造管した。これらの機械特性、耐水素遅れ割れ試験結果を表５に示す。

【００７０】

【表４】

鋼	番号	Ar3 (℃)	熱延条件 加熱温度 (℃)	熱延条件 仕上温度 (℃)	熱延条件 巻取温度 (℃)	連続焼鈍炉熱処理条件 加熱温度 (℃)	連続焼鈍炉熱処理条件 焼戻し温度 (℃)	造管条件 板厚 t (mm)	造管条件 外径 D (mm)	造管条件 縮径率 Q (%)	造管条件 Q/(t/D)^2	ミクロ組織 マルテンサイト分率 (%)	
A	7	790	1200	860	520	880	220	2.0	31.8	6.0	1520	100	発明例
	8		1160	850	580	890	240	2.0	31.8	6.0	1520	100	
	9		1230	860	670	880	220	2.0	31.8	6.0	1520	100	比較例
	10		1220	840	590	890	180	2.0	31.8	2.0	510	100	
B	11	780	1210	830	600	810	210	1.6	38.1	2.0	1130	90	発明例
	12		1170	850	600	870	230	1.8	31.8	4.8	1500	100	
	13		1180	820	590	860	180	2.0	31.8	8.2	2070	100	
	14		1120	830	600	860	190	2.0	31.8	8.2	2070	100	比較例
	15		1280	750	620	880	200	2.0	31.8	6.0	1520	100	
C	16	760	1220	830	580	860	200	1.6	31.8	4.8	1900	100	発明例
	17		1250	820	570	840	220	2.0	31.8	9.0	2280	100	
	18		1250	830	550	760	210	1.6	31.8	4.8	1900	100	比較例
	19		1240	860	560	850	190	2.0	38.1	9.0	3270	100	
D	20	760	1250	840	610	860	210	1.6	31.8	3.2	1260	100	発明例
	21		1230	880	600	870	210	2.0	31.8	6.0	1520	100	
	22		1180	870	600	940	230	1.6	31.8	3.2	1260	100	比較例
	23		1190	830	540	850	340	2.0	31.8	6.0	1520	100	
E	24	760	1210	850	580	860	200	1.6	38.1	5.2	2950	100	発明例
	25		1210	840	560	880	200	1.8	31.8	6.0	1870	100	
	26		1230	850	620	870	230	2.0	38.1	2.8	1020	100	
	27		1210	880	630	860	220	2.0	31.8	5.2	1310	100	
	28		1240	860	590	870	20	1.6	31.8	2.8	1110	100	比較例
	29		1200	860	590	860	200	1.8	31.8	9.8	3060	100	
	30		1190	840	550	850	230	2.0	31.8	2.8	710	100	

【００７１】　【表５】

鋼	番号	引張特性 TS (MPa)	三点曲げ特性 最大荷重 (kW)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	
A	7	１２２０	１１．０	２１４０	発明例
	8	１２８０	１３．６	２１４０	
	9	１１８０	１２．９	９５０	比較例
	10	１２４０	９．８	９５０	
B	11	１０６０	１７．０	２３８０	発明例
	12	１２９０	１４．７	２１４０	
	13	１３５０	１６．８	２１４０	
	14	１３２０	１４．２	９５０	比較例
	15	１３９０	１６．６	９５０	
C	16	１４８０	２２．１	３３３０	発明例
	17	１４２０	１７．３	３３３０	
	18	８９０	２４．３	３３３０	比較例
	19	１５１０	１７．９	９５０	
D	20	１５２０	２２．１	２１４０	発明例
	21	１４９０	１７．３	２１４０	
	22	１４８０	２４．３	９５０	比較例
	23	１５００	１７．９	９５０	
E	24	１５３０	１５．４	３１００	発明例
	25	１５１０	１５．１	３１００	
	26	１４７０	１６．４	３１００	
	27	１４８０	１６．９	３１００	
	28	１４３０	１８．４	９５０	比較例
	29	１４１０	１７．６	４８０	
	30	１５００	１８．２	９５０	

【００７２】表５から理解されるように、熱延条件、連続焼鈍炉における熱処理条件、造管条件が本発明で規定した条件を満たしている実施例の電縫鋼管は、引張強度が９８０N／mm^2 以上でかつ割れ発生限界歪みが高く、優れた耐水素遅れ割れ特性を有することが確認された。

【００７３】（実施例３）表６に示すG～Lの６種の鋼＊を溶製し、表７に示すように本発明で規定した熱延条件および造管条件にて３４．８mmφ×２．３mmtの電縫鋼管を作製した。そして、これら鋼管の引張強度および耐水素割れ特性の指標である水素遅れ割れ発生限界付加歪みΔε$_c$ を測定した。結果を表８に示す。

【００７４】

【表６】

鋼	化学成分 (wt%)												備考
	C	Si	Mn	P	S	Al	Cr	Cu	Ni	Nb	V	N	
G	0.12	0.42	1.90	0.01	0.002	0.03	0.47	0.02	0.01	0.000	0.000	0.003	発明材
H	0.15	0.41	1.51	0.01	0.003	0.04	0.42	0.30	0.02	0.000	0.000	0.003	
I	0.15	0.40	1.80	0.01	0.002	0.03	0.46	0.01	0.01	0.010	0.000	0.004	
J	0.18	0.38	1.79	0.01	0.002	0.03	0.46	0.01	0.01	0.000	0.000	0.003	
L	0.18	0.41	1.81	0.01	0.001	0.03	0.44	0.22	0.01	0.000	0.000	0.003	
K	0.23	0.40	1.82	0.01	0.002	0.03	0.02	0.01	0.02	0.000	0.000	0.003	比較材

【００７５】

【表７】

鋼	番号	Ar3温度(℃)	熱延条件 仕上温度(℃)	30%圧下温度(℃)	冷却速度℃/s	保持時間(s)	巻取温度(℃)	造管条件 板厚t(mm)	外径D(mm)	幅絞り率Q(%)	$Q/(t/D)^2$	組織 焼戻しマルテンサイト分率(%)	備考
G	1	820	900	925	130	2.5	80	2.3	34.0	6.5	1420	100	発明例
H	2	810	910	940	120	2.3	70	2.3	34.0	6.5	1420	100	発明例
I	3	810	880	905	125	2.8	60	2.3	34.0	6.5	1420	100	発明例
J	4	800	890	915	110	2.2	70	2.3	34.0	6.5	1420	100	発明例
K	5	800	870	890	115	2.3	50	2.3	34.0	6.5	1420	100	発明例
L	6	790	890	910	120	2.1	50	2.3	34.0	6.5	1420	100	比較例

【００７６】
【表８】

鋼	番号	引張特性 TS (N/mm²)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	備考
A	1	1180	1900	発明例
B	2	1360	2860	発明例
C	3	1390	1900	発明例
D	4	1480	1900	発明例
E	5	1500	2380	発明例
F	6	1640	0	比較例

【００７７】表８に示すように、本発明で規定する組成を満足する鋼Ｇ～Ｊは、いずれも９８０Ｎ／ｍｍ² 以上の強度を示し、かつ１９００μｍ以上の高い水素遅れ割れ発生限界付加歪み$Δε_c$が安定して得られた。また、組織的には表７に示すように１００％焼戻しマルテンサイトであった。一方、Ｃ量が本発明で規定する範囲を外れる鋼Ｌは、強度上の問題はないが、水素遅れ割れ発生限界付加歪み$Δε_c$が著しく低く、耐水素遅れ割れ特性が劣ることが確認された。

【００７８】（実施例４）表６の鋼Ｇ～Ｌを用いて表９に示すように熱延条件および造管条件を種々変化させて電縫鋼板を作製し、これら鋼管の引張強度および耐水素割れ特性の指標である水素遅れ割れ発生限界付加歪み$Δε_c$を測定した。結果を表１０に示す。

【００７９】
【表９】

鋼	番号	Ar3温度(℃)	熱延条件 仕上温度(℃)	30%圧下温度(℃)	冷却速度℃/s	保持時間(s)	巻取温度(℃)	造管条件 板厚t(mm)	外径D(mm)	幅絞り率Q(%)	$Q/(t/D)^2$	組織 焼戻しマルテンサイト分率(%)	備考
G	7	820	850	870	90	2.3	70	2.3	38.1	3.9	1070	85	発明例
	8		890	915	120	2.7	80	2.3	31.8	8.2	1568	100	
	9		900	920	50	2.5	60	2.3	38.1	3.9	1070	60	比較例
	10		920	940	120	2.5	70	2.3	31.8	4.8	918	100	
H	11	810	860	890	90	2.2	80	3.2	31.8	11.8	1165	100	発明例
	12		850	875	125	2.0	90	2.3	34.0	10.5	2295	100	
	13		850	870	95	2.1	60	3.2	38.1	7.5	1063	100	
	14		810	830	90	2.3	100	2.3	38.1	3.9	1070	60	比較例
	15		940	955	130	2.7	60	2.3	31.8	8.2	1568	100	
I	16	810	860	880	120	3.2	70	2.3	38.1	3.9	1070	100	発明例
	17		880	900	85	2.0	60	3.2	31.8	11.8	1165	100	
	18		890	910	105	2.1	90	2.3	38.1	11.8	3238	100	比較例
	19		860	880	80	>2.0	190	3.2	31.8	11.8	1165	*1	
J	20	800	890	915	120	2.3	80	2.3	38.1	3.9	1070	100	発明例
	21		900	930	115	2.7	70	2.0	34.0	9.5	2746	100	
	22		900	930	110	2.1	60	2.0	34.0	6.5	1879	100	
	23		900	925	110	2.4	60	2.3	31.8	8.2	1568	100	
	24		880	910	105	1.1	80	2.3	38.1	3.9	1070	*2	比較例
	25		860	910	110	2.1	70	2.0	34.0	6.5	1879	100	
	26		890	910	100	2.1	60	2.0	38.1	9.6	3484	100	
K	27	800	900	925	120	2.2	60	2.3	34.0	6.5	1420	100	発明例
	28		850	880	105	2.1	80	2.0	31.8	7.2	1820	100	
	29		860	880	105	1.3	80	2.0	34.0	6.5	1879	*2	比較例
	30		840	865	90	2.2	100	2.3	31.8	3.9	746	100	

*1：ベイナイト100%　　*2：焼入れままマルテンサイト100%

【００８０】
【表１０】

鋼	番号	引張特性 TS (N/mm²)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	備考
G	7	1040	1900	発明例
	8	1210	1900	
	9	810	1900	比較例
	10	1120	950	
H	11	1410	2860	発明例
	12	1360	2860	
	13	1320	2860	
	14	870	2860	比較例
	15	1340	950	
I	16	1270	1900	発明例
	17	1360	1900	
	18	1420	950	比較例
	19	940	1900	
J	20	1480	1900	発明例
	21	1490	1900	
	22	1510	1900	
	23	1520	1900	
	24	1510	950	比較例
	25	1500	950	
	26	1570	950	
K	27	1480	2380	発明例
	28	1510	2380	
	29	1530	950	比較例
	30	1490	950	

【００８１】表１０に示すように、熱延条件、造管条件が本発明の範囲内にある電縫鋼管は、引張強度が９８０N/mm^2で、かつ１９００μm以上の高い水素割れ発生限界歪み$\Delta\varepsilon_c$が安定して得られる。また、組織的には表９に示すように８０％以上の焼戻しマルテンサイトとフェライトからなる複合組織であった。一方、熱処理条件、造管条件が本発明の範囲外の試料では、引張強度が不足したり、水素遅れ割れ発生限界付加歪み$\Delta\varepsilon_c$が９５０μmと低く、かつ安定した$\Delta\varepsilon_c$の値が得られなかった。

【００８２】（実施例５）表１１に示すＭ～Ｓの７種の鋼を溶製し、表１２に示す方法で３１．８ｍｍφ×１．６ｍｍｔの電縫鋼管を作製した。これらの鋼管を０．１Ｎ塩酸中に２００時間浸漬し、浸漬前後で引張試験を行い残留強度率を求め、耐久性の指標とした。なお、残留強度率（％）は前述した方法で求めた。その結果を表１３に示す。

【００８３】

【表１１】

(wt. %)

鋼	C	Si	Mn	P	S	Al	Nb	Cu	Cr	Ni	Mo	Ti	B	N	
M	0.15	0.35	1.78	0.01	0.005	0.03	0.015	0.22	0.02	tr	tr	tr	tr	0.002	発明例
N	0.15	0.36	1.40	0.02	0.003	0.02	0.014	0.40	0.01	tr	tr	0.01	0.001	0.003	発明例
O	0.17	0.41	1.80	0.01	0.003	0.03	0.020	0.16	0.01	tr	tr	tr	tr	0.004	発明例
P	0.17	0.33	1.35	0.01	0.001	0.03	0.016	0.15	tr	tr	tr	0.01	0.001	0.002	発明例
Q	0.17	0.41	1.82	0.01	0.002	0.03	tr	0.14	0.42	tr	tr	0.01	0.001	0.003	発明例
R	0.17	0.40	1.50	0.01	0.003	0.03	tr	tr	0.03	tr	tr	tr	tr	0.003	比較例
S	0.23	0.37	1.90	0.01	0.002	0.03	tr	tr	0.03	tr	tr	tr	tr	0.003	比較例

【００８４】

【表１２】

α	スラブ→熱延（インライン焼入れ焼戻し）→スリット→造管
β	スラブ→熱延→連続焼鈍（インライン焼入れ焼戻し）→スリット→造管
γ	スラブ→熱延→冷延→連続焼鈍（インライン焼入れ焼戻し）→スリット→造管
δ	スラブ→熱延→スリット→造管→焼入れ焼戻し
ε	スラブ→熱延→冷延→焼鈍→スリット→造管→焼入れ焼戻し

【００８５】

【表１３】

番号	鋼	製造方法	マルテンサイト分率 (%)	浸漬試験前のTS (N／㎟)	浸漬試験後のTS (N／㎟)	残留強度率 (%)	
1	M	α	80	1220	1040	85	発明例
2	M	γ	100	1420	1180	83	
3	M	δ	100	1400	1200	86	
4	N	α	80	1410	1300	92	
5	N	γ	100	1230	1110	90	
6	N	δ	100	1380	1210	88	
7	O	α	100	1530	1250	82	
8	O	γ	100	1520	1260	83	
9	O	δ	100	1470	1180	80	
10	O	ε	100	1550	1260	81	
11	P	α	100	1450	1190	82	
12	P	β	100	1520	1260	83	
13	P	γ	100	1550	1240	80	
14	P	δ	100	1540	1260	82	
15	Q	α	100	1560	1260	81	
16	Q	δ	100	1530	1250	82	
17	R	α	100	1380	990	72	比較例
18	R	β	100	1420	1040	73	
19	R	γ	100	1500	1110	74	
20	R	δ	100	1510	1120	74	
21	R	ε	100	1500	1080	72	
22	S	α	80	1320	920	70	
23	S	γ	100	1570	—	遅れ破壊割れ	
24	S	δ	100	1550	1010	65	

【００８６】表１３から明らかなように、鋼組成と組織とにおいて本発明で規定された条件を満たしている発明例の電縫鋼管は引張強度が１１８０Ｎ／ｍm_2 以上でかつ残留強度率が高く、優れた耐久性を有することが確認された。

【００８７】

【発明の効果】以上説明したように、本発明によれば、ドアインパクトビームなどの自動車部品、機械構造用部材、土木建築用部材に用いられる引張強度９８０Ｎ／ｍm^2 以上の耐水素遅れ割れ特性に優れた構造用超高張力電縫鋼管を、低コストで製造することができる。

【図面の簡単な説明】

【図１】Ｃｕ添加量と割れ発生限界付加歪み変化量との関係を示す図。

【図２】Ｎｉ添加量と割れ発生限界付加歪み変化量との関係を示す図。

【図３】Ｑ／（ｔ／Ｄ）^{2} と水素遅れ割れ発生限界付加歪みとの関係を示す図。

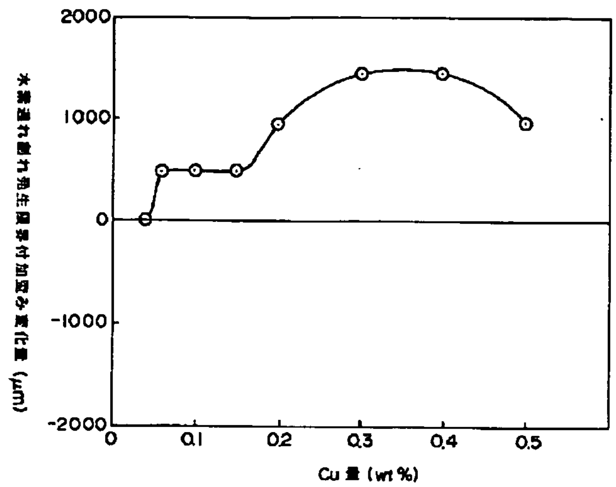
【図４】１５０～２５０℃の温度範囲における保持時間と水素遅れ割れ発生限界付加歪みΔε_c との関係を示す図。

【図５】Ｃｕ添加量と腐食試験後の残留強度率の関係を示す図。

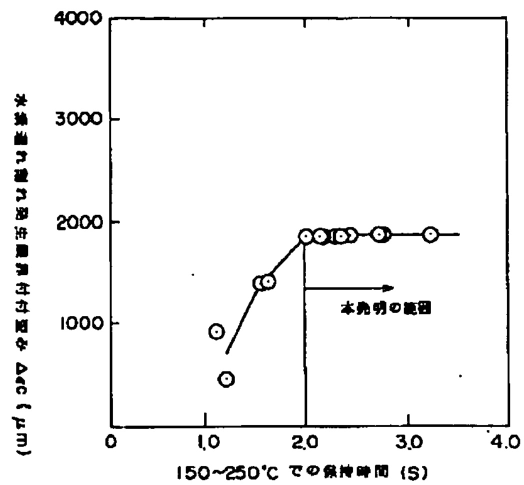
【図６】Ｎｉ添加量と腐食試験後の残留強度率の関係を示す図。

【図７】Ｍｏ添加量と腐食試験後の残留強度率の関係を示す図。

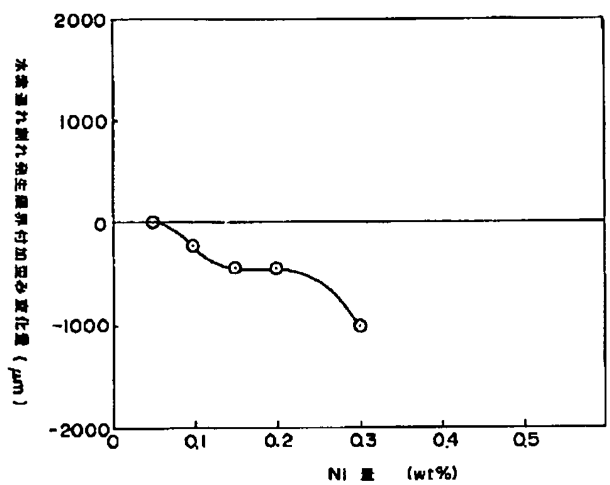
【図１】


2000
1000
0
-1000
-2000
水素遅れ割れ発生限界付加歪み変化量 (μm)
0
0.1
0.2
0.3
0.4
0.5
Cu 量 (wt%)

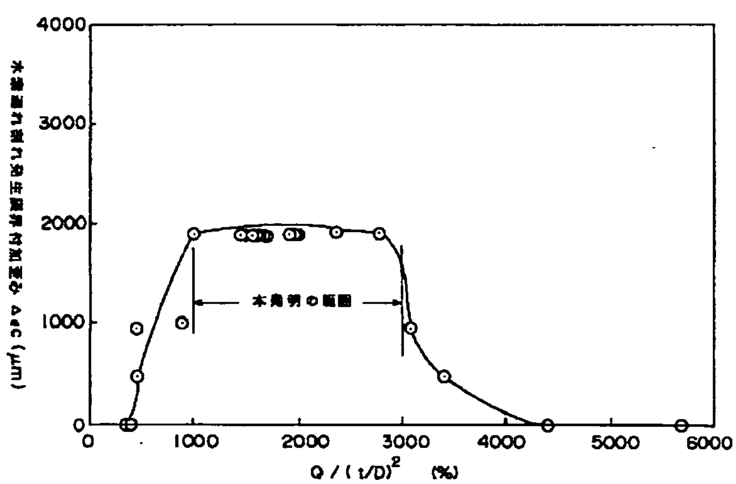
【図４】


4000
3000
2000
1000
水素遅れ割れ発生限界付加歪み Δεc (μm)
本発明の範囲
0
1.0
2.0
3.0
4.0
150~250℃ での保持時間 (S)

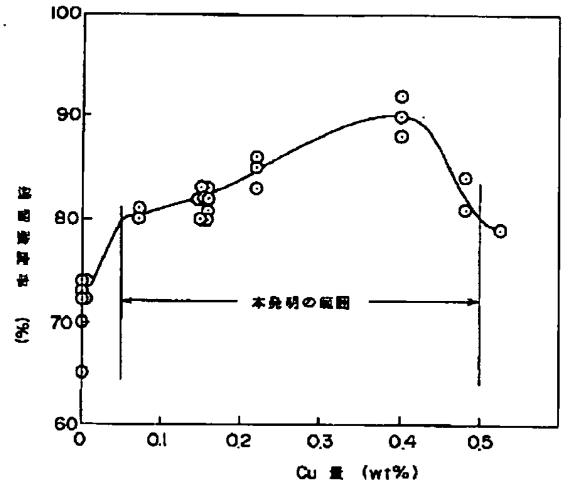
【図２】


2000
1000
0
-1000
-2000
水素遅れ割れ発生限界付加歪み変化量 (μm)
0
0.1
0.2
0.3
0.4
0.5
Ni 量 (wt%)

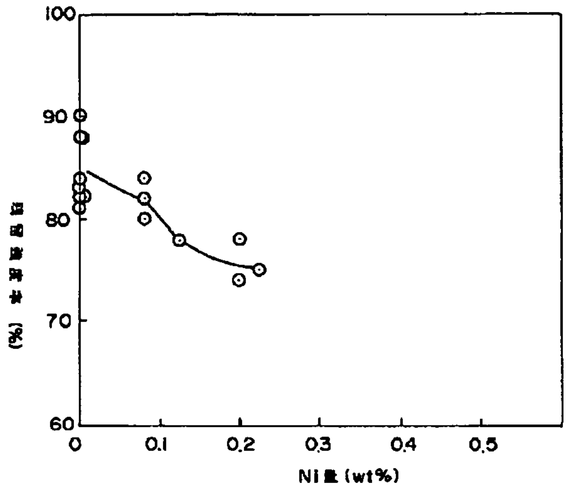
【図３】


4000
3000
2000
1000
0
水素遅れ割れ発生限界付加歪み Δεc (μm)
本発明の範囲
0
1000
2000
3000
4000
5000
6000
Q / (t/D)² (%)

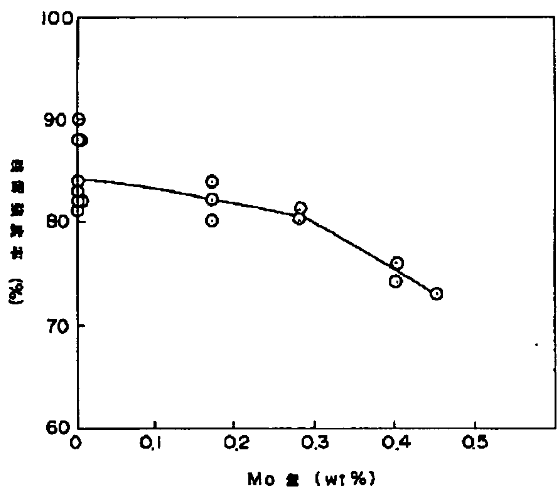
【図５】



【図６】



【図７】



フロントページの続き

(58)調査した分野(Int.Cl.⁷，ＤＢ名)

C21D　8/00 － 8/10

C22C　38/00 － 38/60

CLAIMS

---

(57) [Claim(s)]
[Claim 1] By weight %, C:0.10 - 0.19%, Si:0.01-0.5%, Mn: 0.8-2.2%, aluminum:0.01-0.06%, Cr:0.05-0.6%, It is Ar3 of said steel to the steel slab which consists of the remainder Fe and an unescapable impurity P:0.02% or less, S:0.003% or less, and N:0.005% or less. It is the temperature of the transformation point TAr3 When it carries out, It hot-rolls by controlling finishing temperature Tf so that finishing temperature Tf may become the temperature requirement of -(TAr 3+30) (TAr 3+100) **. In the case of the hot rolling, 30% or more of rolling reduction is given in the temperature requirement of Tf - (Tf+30) **. After cooling to the temperature Tc of a 150-250-degree C temperature requirement with the cooling rate of 60-200 degrees C/sec promptly after hot rolling, The manufacture approach of the super-high tension electroseamed steel pipe which is made to pile up in the temperature requirement below 150-degree-Cor more Tc 2 seconds or more, rolls round at the temperature of less than 150 degrees C, considers as hot rolled sheet steel, and is characterized by forming this hot rolled sheet steel by width-of-face contraction percentage Q which fills the following (1) types.
1000 <=Q/(t/D)2 <=3000 .... (1)
However, board thickness of a t(mm):steel plate, D (mm): The outer diameter of an electroseamed steel pipe and Q (%) are width-of-face contraction percentages, and are defined by the following formulas (2).
Q=[/pi(D-t)] x100 .... (2) [{width-of-face-pi (D-t) of a steel plate pi}]
[Claim 2] Furthermore, the manufacture approach of the super-high tension electroseamed steel pipe according to claim 1 characterized by containing at least one of Nb:0.005-0.03% and V:0.005 - 0.03% of sorts by weight %.
[Claim 3] Furthermore, the manufacture approach of the super-high tension electroseamed steel pipe according to claim 1 or 2 characterized by containing B:0.0005 - 0.0030% by weight %.
[Claim 4] Furthermore, the manufacture approach of a super-high tension electroseamed steel pipe given in any 1 term of claim 1 characterized by containing Cu:0.05-0.50% by weight % thru/or claim 3.
[Claim 5] Furthermore, the manufacture approach of the super-high tension electroseamed steel pipe according to claim 4 characterized by being less than [nickel:0.3%] by weight %.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the member for automobiles, the super-high tension electroseamed steel pipe further used for a machine structural element and an engineering-works structural member, and its manufacture approaches, such as a door impact beam.
[0002]
[Description of the Prior Art] The reinforcing materials called a door impact beam from a viewpoint of safety are prepared in the interior of car Doat, such as an automobile. Although the press cast of cold rolled high tensile strength steel sheets was used for the conventional door impact beam in many cases, tensile strength is 2 980Ns/mm because of recent years and lightweight-izing. The above remarkable high tension electroseamed steel pipe with high reinforcement is adopted increasingly.
[0003] About former and ultrahigh-tensile-strength-steel tubing, it is the steel which has the predetermined chemical entity currently indicated by each official report of JP,1-205032,A, JP,4-131327,A, JP,4-187319,A, JP,6-57375,A, JP,6-88129,A, and JP,6-179913,A the tensile strength of 980Ns/mm 2 After considering as the above high-tensile-steel plate, the method of carrying out electric resistance welding and obtaining a high intensity electroseamed steel pipe is proposed.
[0004] Moreover, hardening processing is performed to the steel pipe which has the predetermined chemical entity currently indicated by each official report of JP,3-122219,A and JP,4-63227,A, and it is 2 the tensile strength of 1180Ns/mm. The method of obtaining the above high tension electroseamed steel pipe is proposed.
[0005]
[Problem(s) to be Solved] Since residual distortion exists with tubulation, consideration of as opposed to a hydrogen delay crack on the occasion of the practical use is required for the approach shown in each official report of above-mentioned JP,1-205032,A, JP,4-131327,A, JP,4-187319,A, JP,6-57375,A, JP,6-88129,A, and JP,6-179913,A etc.
[0006] However, the approach shown until now is not enough, even if the consideration to a hydrogen delay crack is not made, or it is and is released [are and], therefore need amplification of ultrahigh-tensile-strength-steel tubing is restricted.
[0007] On the other hand, although the approach shown in each official report of JP,3-122219,A and JP,4-63227,A does not have the residual distortion of ****, when corrosion progresses during the activity, it is a problem that shell reinforcement falls.
[0008] This invention is made in view of this situation, and its tensile strength is high, and or it excelled in the hydrogen-proof delay crack property, it aims at offering the super-high tension electroseamed steel pipe which was excellent also in corrosion resistance in addition to this, and its manufacture approach.
[0009]
[Means for Solving the Problem] In order to attain said object, as a result of performing many experimental examination, or this invention persons were excellent in the hydrogen-proof delay

•crack property by rationalizing the heat treatment conditions and tubulation conditions of adjustment of a steel component, and a steel plate, and adjusting an organization, they acquired the knowledge of becoming possible to obtain the super-high tension electroseamed steel pipe which was excellent also in corrosion resistance in addition to this.
[0010] It is made based on such knowledge and this invention is [0011]. By weight %, C:0.10 - 0.19%, Si:0.01-0.5%, Mn: 0.8-2.2%, aluminum:0.01-0.06%, Cr:0.05-0.6%, It is Ar3 of said steel to the steel slab which consists of the remainder Fe and an unescapable impurity P:0.02% or less, S:0.003% or less, and N:0.005% or less. It is the temperature of the transformation point TAr3 When it carries out, It hot-rolls by controlling finishing temperature Tf so that finishing temperature Tf may become the temperature requirement of -(TAr 3+30) (TAr 3+100) **. In the case of the hot rolling, 30% or more of rolling reduction is given in the temperature requirement of Tf - (Tf+30) **. After cooling to the temperature Tc of a 150-250-degree C temperature requirement with the cooling rate of 60-200 degrees C/sec promptly after hot rolling, The manufacture approach of the super-high tension electroseamed steel pipe which is made to pile up in the temperature requirement below 150-degree-Cor more Tc 2 seconds or more, rolls round at the temperature of less than 150 degrees C, considers as hot rolled sheet steel, and is characterized by forming this hot rolled sheet steel by width-of-face contraction percentage Q which fills the following (1) types is offered.
[0012]
1000 <=Q/(t/D)2 <=3000 .... (1)
However, board thickness of a t(mm):steel plate, D (mm): The outer diameter of an electroseamed steel pipe and Q (%) are width-of-face contraction percentages, and are defined by the following formulas (2).
Q=[/pi(D-t)] x100 .... (2) [{width-of-face-pi (D-t) of a steel plate pi}]
[0013]
[Embodiment of the Invention] The super-high tension electroseamed steel pipe of this invention is begun and attained by controlling a component presentation and organization of steel. the 1st operation gestalt and the 2nd operation gestalt of this invention -- therefore, heat treatment conditions, tubulation conditions, etc. of a steel plate of a specific component presentation are specified, and the 3rd operation gestalt specifies a component presentation and the organization itself of steel.
[0014] Hereafter, each operation gestalt is explained to a detail.
(1) The 1st operation gestalt (chemical composition) tensile strength is 2 980Ns/mm. Above In order to acquire the outstanding hydrogen-proof delay crack property, and C:0.10 - 0.19%, Si: 0.01-0.5%, Mn:0.8-2.2%, aluminum:0.01-0.06%, Nb: Specify to the presentation restricted to less than [Ti:0.015%] including 0.005-0.03% and B:0.0005 - 0.0030% further P:0.02% or less, S:0.003% or less, and N:0.005% or less. Moreover, Cu:0.05-0.50% is added as a selection component. In that case, although nickel may be added, it may be less than [nickel:0.10%].
[0015] Hereafter, the reason for definition of each element is explained.
C: C is an indispensable element, in order to make desired martensite generate and to secure target reinforcement. However, 980N/mm2 made into a target for a content to be less than 0.10% The above reinforcement is not obtained, but on the other hand, if a content exceeds 0.19%, tensile strength will become high too much, or the carbide size which deposits at the time of annealing will become large, and a hydrogen-proof delay crack property will deteriorate anyway. Therefore, the content of C is made into 0.10 - 0.19%.
[0016] Si: It is added in order that Si may secure the soundness of the electric-resistance-welding section, and since the content is demonstrated at 0.01 - 0.5%, the effectiveness makes the content of Si 0.01 - 0.5%.
[0017] Mn: Mn is an indispensable element, in order to raise the hardenability of an austenite, to make desired martensite generate and to secure target reinforcement. However, 980N/mm2 made into a target for a content to be less than 0.8% The above reinforcement is not obtained, but on the other hand, if a content exceeds 2.2%, a hydrogen-proof delay crack property will deteriorate. Therefore, the content of Mn is made into 0.8 - 2.2%.
[0018] aluminum: aluminum fixes as AlN N which is added as a deoxidation element and exists as

an impurity in steel, and raises a hydrogen-proof delay crack property. However, if it is few at less than 0.01% and, as for the addition effectiveness, exceeds 0.06% on the other hand, inclusion will increase and a hydrogen-proof delay crack property will deteriorate. Therefore, the content of aluminum is made into 0.01 - 0.06%.
[0019] Nb : Nb is an element which controls the austenite grain growth at the time of heating in a continuous annealing furnace, makes martensitic structure detailed, and raises a hydrogen-proof delay crack property. The addition effectiveness is accepted at 0.005% or more, and on the other hand, even if it adds exceeding 0.02%, the addition effectiveness is saturated. Therefore, the content of Nb is made into 0.005 - 0.02%.
[0020] B: B is an element required in order to make desired martensite generate and to secure target reinforcement. However, 980N/mm2 made into a target for an addition to be less than 0.0005% The above reinforcement is not obtained, but on the other hand, even if an addition exceeds 0.0030%, the addition effectiveness is saturated. Therefore, the content of B is made into 0.0005 - 0.0030%.
[0021] P: P needs to regulate to 0.02% or less in order to degrade a delayed fracture-proof property.
S: In order for S to exist as inclusion and to degrade a hydrogen-proof delay crack property, to regulate to 0.003% or less is required.
[0022] N: Since a hydrogen-proof delay crack property will fall if N is contained exceeding 0.005%, the need has regulated to 0.005% or less.
Ti: If Ti deposits as a big and rough nitride, since it will reduce a hydrogen-proof delay crack property, not adding is desirable. However, Dissolution N is fixed as TiN, and in order to secure the hardenability of B, to add reluctantly, it is necessary to make the addition into 0.015% or less.

[0023] Cu : Cu is an element which controls progress of the corrosion of a steel pipe, and controls trespass of the hydrogen to the inside of a steel pipe, and raises a hydrogen-proof delay crack property. The addition effectiveness is accepted at 0.05% or more, and the addition effectiveness is saturated even if it adds exceeding 0.50% on the other hand. Therefore, in adding Cu, it makes the content into 0.05 - 0.50%.
[0024] The relation between Cu addition and the variation of crack generating marginal addition distortion (deltaepsilon) is shown in drawing 1 . It is understood that crack generating marginal addition distortion (deltaepsilon) increases, and a hydrogen delay crack is controlled by Cu addition from this drawing.
[0025] nickel: As for nickel, it is desirable not to add in order to promote local corrosion and to reduce a hydrogen-proof delay crack property by the casting segregation. However, in order to avoid Cu crack at the time of hot-rolling, in adding reluctantly, lowering of a hydrogen-proof delay crack property makes a content 0.10% or less which is not remarkable.
[0026] The relation between nickel addition and the variation of crack generating marginal addition distortion (deltaepsilon) is shown in drawing 2 . It is understood that crack generating marginal addition distortion (deltaepsilon) decreases, and a hydrogen delay crack is promoted by nickel addition from this drawing.
[0027] After carrying out soak of the steel slab of the above-mentioned chemical composition at 1150-1300 degrees C, (Manufacture conditions) It is Ar3 to this slab. The hot rolling which makes beyond a point finishing temperature is performed. It rolls round at 500-650 degrees C, and considers as a hot-rolling steel strip. This hot rolled sheet steel After the acid-washing cold press, It quenches after soak heating at 800-900 degrees C with a continuous annealing furnace, and tempering processing is performed at further 150-250 degrees C, and the obtained steel plate is formed by width-of-face contraction percentage Q which fills the following (1) types, and it considers as a 80 - 100% tempered martensite + remainder ferrite.
[0028] A. Whenever [hot rolling condition a. slab stoving temperature], whenever [slab stoving temperature] needs to be 1150 degrees C or more, in order to make Nb dissolve. If whenever [slab stoving temperature] does not fulfill 1150 degrees C, it is solute drug with sufficient Nb at the time of heating in a continuous annealing furnace. In order not to demonstrate effectiveness, martensitic structure does not become detailed and the improvement effectiveness of the

hydrogen-proof delay crack property by Nb addition is not acquired. On the other hand, the upper limit of whenever [slab stoving temperature] is made into 1300 degrees C from an operable viewpoint.
[0029] b. Finish rolling temperature finish rolling temperature is Ar3. It is necessary to be beyond a point. Finish rolling temperature is Ar3. It is solute drug with sufficient Nb at the time of heating [in / that it is below a point / by distorted induction deposit of Nb carbon nitride in the ferrite transformation section / a continuous annealing furnace]. In order not to demonstrate effectiveness, martensitic structure does not become detailed and the improvement effectiveness of the hydrogen-proof delay crack property by Nb addition is not acquired.
[0030] c. Make winding temperature winding temperature into 500-650 degrees C. If winding temperature exceeds 650 degrees C, Nb carbide will make it big and rough, and it does not re-dissolve at the time of heating in a continuous annealing furnace, but is sufficient solute drug. In order not to demonstrate effectiveness, martensitic structure does not become detailed and the improvement effectiveness of the hydrogen-proof delay crack property by Nb addition is not acquired. On the other hand, a hot-rolling steel strip makes it hard that winding temperature is less than 500 degrees C, and it becomes an operation top problem.
[0031] B. Make whenever [in a continuous annealing furnace / stoving temperature] into 800-900 degrees C whenever [in a continuous annealing furnace / heat treatment condition a. stoving temperature]. The amount of martensite of amount sufficient after quenching at less than 800 degrees C is not obtained, and target reinforcement is not obtained. On the other hand, if 900 degrees C is exceeded, detailed martensitic structure will not be obtained by austenite grain big and rough-ization at the time of heating, but a hydrogen-proof delay crack property will fall.
[0032] b. The steel strip made into the 80 - 100% martensite + remainder ferrite obtained by tempering heat treatment condition heating-quenching performs tempering processing in a 150-250-degree C temperature requirement. In the tempering temperature of less than 150 degrees C, martensitic transformation distortion remains and the hydrogen-proof crack nature after tubulation falls. On the other hand, if tempering temperature exceeds 250 degrees C, the cementite phase which deposits with annealing will become big and rough, and a delayed fracture-proof property will fall.
[0033] C. Width-of-face drawing in the tubulation process of tubulation condition electric-resistance-welding-sizing is the important requirements for cheating out of the hydrogen-proof delay crack property of a steel pipe good, and after for that controlling width-of-face contraction percentage Q within limits shown by (1) formula, it forms a tube.
[0034]
1000 <=Q/(t/D)2 <=3000 .... (1)
However, board thickness of a t(mm):steel plate, D (mm): The outer diameter of an electroseamed steel pipe and Q (%) are width-of-face contraction percentages, and are defined by the following formulas (2).
Q=[/pi(D-t)] x100 .... (2) [{width-of-face-pi (D-t) of a steel plate pi}]
It is Q/2 (t/D) to drawing 3 . Hydrogen delay crack generating marginal addition distortion deltaepsilonc Relation is shown. As a result of this invention persons' performing many experimental examination about tubulation conditions and a hydrogen-proof delay crack property, as shown in drawing 3 , for the hydrogen delay crack generating marginal addition distortion of a steel pipe, width-of-face contraction percentage Q is 1000(t/D) 2 -3000(t/D) 2. It had a peak in between and found out that the steel pipe which has the hydrogen-proof delay crack property excellent in controlling a width-of-face contraction percentage in this range was obtained. This proper width-of-face contraction percentage is a product (board thickness/outer diameter). In order to obtain the steel pipe which changes with ratios and has the outstanding hydrogen-proof delay crack property (board thickness/outer diameter) It is necessary to take a different width-of-face contraction percentage for every ratio.
[0035] The hydrogen-proof delay crack property of a steel pipe is width-of-face contraction percentage Q=1000(t/D) 2 -3000(t/D) 2. The reason for having a peak in between is considered as follows. That is, a width-of-face contraction percentage is 1000(t/D) 2. In not filling, the

maximum residual distortion of a steel pipe increases, the hydrogen-proof delay crack property of a steel pipe deteriorates, and a width-of-face contraction percentage is 3000(t/D) 2 to reverse. In exceeding, tubulation rolling texture is formed with tubulation, the hydrogen-proof delay crack sensitivity of a steel pipe increases, and the hydrogen-proof delay crack property of a steel pipe deteriorates.

[0036] In addition, hydrogen delay crack generating marginal addition distortion deltaepsilonc After cutting down C-ring test piece with a width of face of 20mm, performing bolting to the outer diameter before logging and adding distortion of the residual distortion of a steel pipe from an electroseamed steel pipe, the addition distortion of the limitation which the crack at the time of adding addition distortion (deltaepsilon) further calculate by the following (3) formulas, being immerse into 0.1-N hydrochloric acid for 200 hours, and investigating crack generating existence generate be point out. Let this value be the index of a hydrogen-proof delay crack property. Namely, for a hydrogen-proof delay crack property, it is so desirable that this value is high.

[0037]

deltaepsilon=(4, 106, and t-delta)/(pi-D- (D-t)) .... (3)

Here, t is [the outer diameter of the steel pipe before logging and delta of board thickness and D] D- (outer diameter after addition distortion addition).

[0038] Tensile strength 980N/mm2 which were excellent in the hydrogen-proof delay crack property by forming a 80 - 100% tempered martensite + remainder ferrite by the above approaches The above electroseamed steel pipe is manufactured.

[0039] (2) The 2nd operation gestalt (chemical composition) tensile strength is 2 980Ns/mm. Above In order to acquire the outstanding hydrogen-proof delay crack property, by weight % And C:0.10 - 0.19%, Si: Specify to the presentation restricted to P:0.02% or less, S:0.003% or less, and N:0.005% or less including 0.01-0.5%, Mn:0.8-2.2%, aluminum:0.01-0.06%, and Cr:0.05-0.6%. Moreover, Nb:0.005-0.03% and V:0.005 - 0.03% of inside [at least one sort, B:0.0005 - 0.0030%, and Cu:0.05-0.50% of] is added as a selection component. Moreover, although nickel may be added when Cu is added, it may be less than [nickel:0.30%].

[0040] Hereafter, the reason for definition of each element is explained. The reason for definition of C, Si, Mn, and aluminum is the same as the above-mentioned 1st operation gestalt.

Cr : It is an element for securing raising and target reinforcement by the interaction with Mn. [hardenability / of steel] If the effectiveness is scarce in the content being less than 0.05% and it exceeds 0.6% on the other hand, a hydrogen-proof delay crack property will deteriorate. Therefore, the content of Cr is made into 0.05 - 0.6%.

[0041] About P, S, and N, it is restricted to the above-mentioned range by the same reason as the 1st operation gestalt.

Nb, V : Since each of Nb(s) and V can make the austenite grain before a transformation detailed and the martensite packet after a transformation can be made detailed, it is an element desirable to improvement in a hydrogen-proof delay crack property. However, at less than 0.005%, if there is little the effectiveness and it adds exceeding 0.03% on the other hand, a hydrogen-proof delay crack property will deteriorate on the contrary, respectively. Therefore, the content of Nb and V is made into 0.005 - 0.03%, respectively.

[0042] B: B makes desired martensite generate, and in order to secure target reinforcement, it is added if needed. However, 980N/mm2 made into a target for an addition to be less than 0.0005% The above reinforcement is not obtained, but the addition effectiveness is saturated even if an addition exceeds 0.0030% on the other hand. Therefore, in adding the content of B, it may be 0.0005 - 0.0030%.

[0043] In adding by the same reason as ** and the 1st operation gestalt just to Cu, it considers as 0.05 - 0.50% of range. If the amount of Cu(s) is increased, the surface discontinuity called Cu crack depending on the case may occur, this can be prevented by nickel addition, but since nickel is an element harmful for a hydrogen-proof delay crack property, it is desirable to restrict the addition to 0.3% or less.

[0044] (Manufacture conditions) the steel slab of the above-mentioned presentation -- receiving -- Ar3 of the steel the temperature of the transformation point -- TAr3 **, when it carries out It hot-rolls by controlling finishing temperature Tf so that finishing temperature Tf may become

the temperature requirement of -(TAr 3+30) (TAr 3+100) **. In the case of the hot rolling, 30% or more of rolling reduction is given in the temperature requirement of Tf - (Tf+30) **. After cooling to the temperature Tc of a 150-250-degree C temperature requirement with the cooling rate of 60-200 degrees C/sec promptly after hot rolling, It is made to pile up in the temperature requirement below 150-degree-Cor more Tc 2 seconds or more, and it rolls round at the temperature of less than 150 degrees C, and considers as hot rolled sheet steel, and this hot rolled sheet steel is formed by width-of-face contraction percentage Q which fills the above-mentioned (1) formula.
[0045] A. Hot-rolling condition a. finishing-temperature finishing temperature Tf is taken as the temperature requirement of -(TAr 3+30) (TAr 3+100) **. It is 2 that finishing temperature is under ** (TAr 3+30) 980Ns/mm. The rate of the volume of the martensite for obtaining the above reinforcement is not obtained. On the other hand, if ** (TAr 3+100) is exceeded, a martensite packet will make it big and rough, and a hydrogen-proof delay crack property will fall.
[0046] b. In order to make pressing-down condition martensite detailed and to make a hydrogen-proof delay crack property good, the bottom of the pressure in front of hot rolling termination is required. For this reason, it hot-rolls by giving 30% or more of rolling reduction in the temperature requirement of Tf - (Tf+30) **.
[0047] B. Quench to Tc of a 150-250-degree C temperature requirement with the cooling rate of 60-200 degrees C/sec promptly after the cooling condition hot rolling after hot rolling. Thereby, it is 2 980Ns/mm. The rate of the martensite volume for obtaining the above reinforcement is securable. The martensite of the rate of the volume of the request by cooling rates being under 60 degrees C / sec cannot be obtained. Moreover, if a cooling rate exceeds 200 degrees C/sec, the trouble on operation will be produced. If higher about cooling-shut-down temperature than 250 degrees C, the martensite of the desired rate of the volume will not be obtained.
[0048] Thus, after quenching, it is made to pile up in the temperature requirement below 150-degree-Cor more Tc 2 seconds or more. Thereby, hard tempered martensite is generated. The relation between the holding time when holding the steel plate which drawing 4 quenched in a 150-250-degree C temperature requirement, and hydrogen delay crack generating marginal addition distortion deltaepsilon is shown. From this drawing, it is stabilized by maintenance for 2 seconds or more, and is the high hydrogen delay crack generating marginal addition distortion deltaepsilonc near 2000 micrometers. It turns out that it is obtained. Since hardening distortion remains in less than 2 seconds, it is high deltaepsilonc 1900 micrometers or more. It cannot stabilize and obtain.
[0049] C. Perform winding temperature winding at the temperature of less than 150 degrees C. This temperature does not serve as a hard tempering martensitic phase above 150 degrees C, but it is 2 980Ns/mm. The above reinforcement is not obtained.
[0050] D. tubulation conditions -- although a tube is formed to a super-high tension electroseamed steel pipe using the hot rolled sheet steel manufactured on the above conditions, it is necessary to fill the above-mentioned (1) formula like the above-mentioned 1st operation gestalt in that case
[0051] (3) The 3rd operation gestalt (chemical composition and organization) tensile strength is 2 980Ns/mm. It is above, and in order to acquire the hydrogen-proof delay crack nature and corrosion resistance which were moreover excellent, it has the presentation containing C:0.13 - 0.19%, Mn:1.0-2.0%, and Cu:0.05-0.50%, and considers as 80 - 100% of martensite or the tempering martensitic structure obtained by hardening heat treatment. Moreover, when adding nickel and Mo, it is restricted to less than [nickel:0.1%] and less than [Mo:0.3%].
[0052] Hereafter, the reason for definition of each element is explained.
C: C is an indispensable element, in order to make desired martensite generate and to secure target reinforcement. However, 1180N/mm2 made into a target for a content to be less than 0.13% The above reinforcement is not obtained, but on the other hand, if a content exceeds 0.19%, the shell lowering on the strength by the hydrogen delay crack or corrosion will be promoted, and endurance will deteriorate. Therefore, the content of C is made into 0.13 - 0.19%.
[0053] Mn: Mn is an indispensable element, in order to make desired martensite generate and to secure target reinforcement. However, 1180N/mm2 made into a target for a content to be less

than 1.0% The above reinforcement is not obtained but, on the other hand, the hydrogen-proof delay crack to which a content exceeds 2.0%, or a corrosion property deteriorates. Therefore, the content of Mn is made into 1.0 - 2.0%.
[0054] Cu : Cu is an element which lowers the hydrogen delay crack sensitivity of a steel pipe, controls progress of the shell lowering on the strength by corrosion further, and raises the endurance of a super-high tension electroseamed steel pipe. The addition effectiveness is accepted at 0.05% or more, and the addition effectiveness is saturated even if it adds exceeding 0.50% on the other hand. Therefore, in adding Cu, it makes the content into 0.05 - 0.50%.
[0055] The relation between Cu addition and the rate of retained strength after a corrosion test is shown in drawing 5 . The rate of retained strength increases by Cu addition from this drawing, and it is understood that the endurance of a steel pipe increases. In addition, the rate of retained strength can be expressed with the following formulas.
[0056] rate (%) of retained strength ={TS(N/mm2) before TS (N/mm2)/immersion test after immersion test} x100 -- here -- the tubing cross section (mm2) before the **** (breaking load N) / immersion test before TS(N/mm2) = immersion test before an immersion test
The tubing cross section before the **** (breaking load N) / immersion test after TS(N/mm2) = immersion test after an immersion test (mm2)
It comes out.
[0057] nickel: As for nickel, it is desirable not to add in order to promote local corrosion and to reduce a hydrogen-proof delay crack property by the casting segregation. However, in order to avoid Cu crack at the time of hot-rolling, in adding reluctantly, decline in the rate of retained strength makes a content 0.10% or less which is not remarkable.
[0058] Mo: As for Mo, it is desirable not to add in order to promote local corrosion and to reduce a hydrogen-proof delay crack property by the casting segregation. However, in order to secure hardenability, in adding reluctantly, decline in the rate of retained strength makes a content 0.30% or less which is not remarkable.
[0059] The relation between nickel addition and the retained strength after a corrosion test is shown in drawing 6 , and the relation between Mo addition and the rate of retained strength after a corrosion test is shown in drawing 7 . The rate of retained strength decreases from these drawings by addition of 0.1% or less of nickel, and 0.3% or less of Mo, and it is understood that the endurance of a steel pipe falls.
[0060] No elements other than these doing especially big effect to the endurance of a steel pipe, i.e., hydrogen-proof delay crack nature, and corrosion resistance, therefore usually carrying out amount proper addition of the alloy alloying elements, such as Si, P, aluminum, Nb, B, Ti, and Cr, according to other objects is permitted.
[0061] Hardening heat treatment of the steel which has the above presentation is carried out, and it considers as 80 - 100% of martensite, or tempering martensitic structure. By considering as above presentations and organizations, it is 2 the tensile strength of 980Ns/mm. Above, the super-high tension electroseamed steel pipe excellent in endurance, i.e., hydrogen-proof delay crack nature, and corrosion resistance is obtained.
[0062] (Manufacture conditions) If it faces manufacturing the electroseamed steel pipe concerning this 3rd operation gestalt and 80 - 100% of martensite or tempering martensitic structure is obtained by hardening heat treatment, that manufacture approach is not limited but can also be manufactured on the manufacture conditions of the above-mentioned 1st operation gestalt and the 2nd operation gestalt.
[0063]
[Example] Hereafter, the example of this invention is explained.
(Example 1) Six sorts of steel of A-F shown in a table 1 was ingoted, and the electroseamed steel pipe of 31.8mmphix1.6mmt was produced on the hot-rolling conditions specified by this invention as shown in a table 2, the heat treatment conditions in a continuous annealing furnace, and tubulation conditions.
[0064] While measuring the tensile strength of these steel pipes, and three-point bending maximum load, the hydrogen-proof delay cracking test was carried out. The three-point bending test was performed by push metallic-ornaments radius =152mm and support span =600mm. a

hydrogen-proof delay cracking test add addition distortion (deltaepsilon) further calculate by the above-mentioned (3) formula after cut down C-ring test piece with a width of face of 20mm, perform bolting to the outer diameter before logging and add distortion of the residual distortion of a steel pipe from a steel pipe, and be 200 in 0.1-N hydrochloric acid. time amount immersion be carried out, crack generating existence be investigated and crack generating marginal addition distortion be made into the index of a hydrogen-proof delay crack property. A result is shown in a table 3.

[0065]

[A table 1]

鋼	化学成分 (wt%)													
	C	Si	Mn	P	S	Al	Nb	Cu	Ni	Ti	B	N		
A	0.12	0.38	1.40	0.01	0.001	0.03	0.015	tr	tr	0.011	0.0008	0.003	790	発明材
B	0.15	0.42	1.01	0.01	0.003	0.04	0.012	tr	tr	0.009	0.0012	0.003	780	
C	0.17	0.39	1.33	0.01	0.002	0.03	0.015	0.33	tr	tr	0.0018	0.002	760	
D	0.17	0.40	1.40	0.01	0.002	0.03	0.013	tr	tr	0.008	0.0012	0.003	760	
E	0.17	0.41	1.35	0.01	0.001	0.03	0.013	0.20	tr	0.010	0.0011	0.003	760	
F	0.23	0.41	1.90	0.01	0.002	0.03	tr	tr	tr	tr	tr	0.004	750	比較材

[0066]

[A table 2]

鋼	番号	Ar3 (℃)	熱延条件			連続焼鈍炉熱処理条件		造管条件				ミクロ組織	
			加熱温度 (℃)	仕上温度 (℃)	巻取温度 (℃)	加熱温度 (℃)	焼戻し温度 (℃)	板厚 t (mm)	外径 D (mm)	縮径率 Q (%)	Q/(t/D)²	マルテンサイト分率 (%)	
A	1	790	1240	830	630	890	200	1.6	31.8	4.9	1940	100	発明例
B	2	780	1230	860	620	860	190	1.6	31.8	4.9	1940	100	
C	3	760	1200	870	610	840	220	1.6	31.8	4.9	1940	100	
D	4	760	1180	850	590	850	220	1.6	31.8	4.9	1940	100	
E	5	760	1210	860	580	870	210	1.6	31.8	4.9	1940	100	
F	6	750	1250	860	610	880	220	1.6	31.8	4.9	1940	100	比較例

[0067]

[A table 3]

鋼	番号	引張特性 TS (MPa)	三点曲げ特性 最大荷重 (kW)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	
A	1	1210	12.1	2140	発明例
B	2	1380	14.0	2140	
C	3	1490	14.8	3330	
D	4	1510	15.6	2140	
E	5	1500	15.5	3100	
F	6	1720	17.5	0	比較例

[0068] Steel A-E which satisfies the presentation specified by this invention had a high crack

generating marginal distortion compared with the comparison steel F, and it was checked that the outstanding hydrogen-proof delay crack property is shown so that I might be understood from a table 3.
[0069] (Example 2) Hot-rolling conditions as shown in a table 4 using above mentioned steel A-E, the heat treatment conditions in a continuous annealing furnace, and tubulation conditions (board thickness/outer diameter), Various ratios were changed and the tube was formed to the electroseamed steel pipe. These mechanical characteristics and a hydrogen-proof delay cracking test result are shown in a table 5.
[0070]
[A table 4]

鋼	番号	Ar3 (℃)	熱延条件 加熱温度 (℃)	熱延条件 仕上温度 (℃)	熱延条件 巻取温度 (℃)	連続焼鈍炉熱処理条件 加熱温度 (℃)	連続焼鈍炉熱処理条件 焼戻し温度 (℃)	造管条件 板厚 t (mm)	造管条件 外径 D (mm)	造管条件 縮径率 Q (%)	造管条件 $Q/(t/D)^2$	ミクロ組織 マルテンサイト分率 (%)	
A	7	790	1200	860	520	880	220	2.0	31.8	6.0	1520	100	発明例
	8		1160	850	580	890	240	2.0	31.8	6.0	1520	100	
	9		1230	860	670	880	220	2.0	31.8	6.0	1520	100	比較例
	10		1220	840	590	890	180	2.0	31.8	2.0	510	100	
B	11	780	1210	830	600	810	210	1.6	38.1	2.0	1130	90	発明例
	12		1170	850	600	870	230	1.8	31.8	4.8	1500	100	
	13		1180	820	590	860	180	2.0	31.8	8.2	2070	100	
	14		1120	830	600	860	190	2.0	31.8	8.2	2070	100	比較例
	15		1280	750	620	880	200	2.0	31.8	6.0	1520	100	
C	16	760	1220	830	580	860	200	1.6	31.8	4.8	1900	100	発明例
	17		1250	820	570	840	220	2.0	31.8	9.0	2280	100	
	18		1250	830	550	760	210	1.6	31.8	4.8	1900	100	比較例
	19		1240	860	560	850	190	2.0	38.1	9.0	3270	100	
D	20	760	1250	840	610	860	210	1.6	31.8	3.2	1260	100	発明例
	21		1230	880	600	870	210	2.0	31.8	6.0	1520	100	
	22		1180	870	600	940	230	1.6	31.8	3.2	1260	100	比較例
	23		1190	830	540	850	340	2.0	31.8	6.0	1520	100	
E	24	760	1210	850	580	860	200	1.6	38.1	5.2	2950	100	発明例
	25		1210	840	560	880	200	1.8	31.8	6.0	1870	100	
	26		1230	850	620	870	230	2.0	38.1	2.8	1020	100	
	27		1210	880	630	860	220	2.0	31.8	5.2	1310	100	
	28		1240	860	590	870	20	1.6	31.8	2.8	1110	100	比較例
	29		1200	860	590	860	200	1.8	31.8	9.8	3060	100	
	30		1190	840	550	850	230	2.0	31.8	2.8	710	100	

[0071]
[A table 5]

鋼	番号	引張特性 TS (MPa)	三点曲げ特性 最大荷重 (kW)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	
A	7	1220	11.0	2140	発明例
	8	1280	13.6	2140	
	9	1180	12.9	950	比較例
	10	1240	9.8	950	
B	11	1060	17.0	2380	発明例
	12	1290	14.7	2140	
	13	1350	16.8	2140	
	14	1320	14.2	950	比較例
	15	1390	16.6	950	
C	16	1480	22.1	3330	発明例
	17	1420	17.3	3330	
	18	890	24.3	3330	比較例
	19	1510	17.9	950	
D	20	1520	22.1	2140	発明例
	21	1490	17.3	2140	
	22	1480	24.3	950	比較例
	23	1500	17.9	950	
E	24	1530	15.4	3100	発明例
	25	1510	15.1	3100	
	26	1470	16.4	3100	
	27	1480	16.9	3100	
	28	1430	18.4	950	比較例
	29	1410	17.6	480	
	30	1500	18.2	950	

[0072] For the electroseamed steel pipe of an example which fulfills the conditions which hot-rolling conditions, the heat treatment conditions in a continuous annealing furnace, and tubulation conditions specified by this invention so that I may be understood from a table 5, tensile strength is 2 980Ns/mm. It was above, and crack generating marginal distortion was high and having the outstanding hydrogen-proof delay crack property was checked.
[0073] (Example 3) Six sorts of steel of G-L shown in a table 6 was ingoted, and the electroseamed steel pipe of 34.8mmphix2.3mmt was produced on the hot-rolling conditions and tubulation conditions which were specified by this invention as shown in a table 7. And hydrogen delay crack generating marginal addition distortion deltaepsilonc which is the index of the tensile strength of these steel pipes, and a hydrogen-proof crack property It measured. A result is shown in a table 8.
[0074]
[A table 6]

鋼	化学成分 (wt%)												備考
	C	Si	Mn	P	S	Al	Cr	Cu	Ni	Nb	V	N	
G	0.12	0.42	1.90	0.01	0.002	0.03	0.47	0.02	0.01	0.000	0.000	0.003	発明材
H	0.15	0.41	1.51	0.01	0.003	0.04	0.42	0.30	0.02	0.000	0.000	0.003	
I	0.15	0.40	1.80	0.01	0.002	0.03	0.46	0.01	0.01	0.010	0.000	0.004	
J	0.18	0.38	1.79	0.01	0.002	0.03	0.46	0.01	0.01	0.000	0.000	0.003	
L	0.18	0.41	1.81	0.01	0.001	0.03	0.44	0.22	0.01	0.000	0.000	0.003	
K	0.23	0.40	1.82	0.01	0.002	0.03	0.02	0.01	0.02	0.000	0.000	0.003	比較材

[0075]
[A table 7]

鋼	番号	Ar3温度 (℃)	熱延条件 仕上温度 (℃)	30%圧下温度 (℃)	冷却速度 ℃/s	保持時間 (s)	巻取温度 (℃)	造管条件 板厚 t (mm)	外径 D (mm)	幅絞り率 Q (%)	$Q/(t/D)^2$	組織 焼戻しマルテンサイト分率 (%)	備考
G	1	820	900	925	130	2.5	80	2.3	34.0	6.5	1420	100	発明例
H	2	810	910	940	120	2.3	70	2.3	34.0	6.5	1420	100	
I	3	810	880	905	125	2.8	60	2.3	34.0	6.5	1420	100	
J	4	800	890	915	110	2.2	70	2.3	34.0	6.5	1420	100	
K	5	800	870	890	115	2.3	50	2.3	34.0	6.5	1420	100	
L	6	790	890	910	120	2.1	50	2.3	34.0	6.5	1420	100	比較例

[0076]
[A table 8]

鋼	番号	引張特性 TS (N/mm²)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	備考
A	1	1180	1900	発明例
B	2	1360	2860	
C	3	1390	1900	
D	4	1480	1900	
E	5	1500	2380	
F	6	1640	0	比較例

[0077] Each steel G-J which satisfies the presentation specified by this invention as shown in a table 8 is 2 980Ns/mm. The above reinforcement is shown and it is the high hydrogen delay crack generating marginal addition distortion deltaepsilonc of 1900 micrometers or more. It was stabilized and obtained. Moreover, as systematically shown in a table 7, it was 100% tempered martensite. On the other hand, for the steel L which separates from the range which the amount of C specifies by this invention, the problem on reinforcement is the hydrogen delay crack generating marginal addition distortion deltaepsilonc, although there is nothing. It was remarkably low and it was checked that a hydrogen-proof delay crack property is inferior.
[0078] (Example 4) Hydrogen delay crack generating marginal addition distortion deltaepsilonc which various hot-rolling conditions and tubulation conditions are changed, a **** steel plate is produced as shown in a table 9 using steel G-L of a table 6, and is the index of the tensile strength of these steel pipes, and a hydrogen-proof crack property It measured. A result is shown in a table 10.
[0079]
[A table 9]

鋼	番号	Ar3温度 (℃)	熱延条件					造管条件				組織	備考
			仕上温度 (℃)	30%圧下温度 (℃)	冷却速度 ℃/s	保持時間 (s)	巻取温度 (℃)	板厚 t (mm)	外径 D (mm)	幅絞り率 Q (%)	$Q/(t/D)^2$	焼戻しマルテンサイト分率 (%)	
G	7	820	850	870	90	2.3	70	2.3	38.1	3.9	1070	85	発明例
	8		890	915	120	2.7	80	2.3	31.8	8.2	1568	100	
	9		900	920	50	2.5	60	2.3	38.1	3.9	1070	60	比較例
	10		920	940	120	2.5	70	2.3	31.8	4.8	918	100	
H	11	810	860	890	90	2.2	80	3.2	31.8	11.8	1165	100	発明例
	12		850	875	125	2.0	90	2.3	34.0	10.5	2295	100	
	13		850	870	95	2.1	60	3.2	38.1	7.5	1063	100	
	14		810	830	90	2.3	100	2.3	38.1	3.9	1070	60	比較例
	15		940	955	130	2.7	60	2.3	31.8	8.2	1568	100	
I	16	810	860	880	120	3.2	70	2.3	38.1	3.9	1070	100	発明例
	17		880	900	85	2.0	60	3.2	31.8	11.8	1165	100	
	18		890	910	105	2.1	90	2.3	38.1	11.8	3238	100	比較例
	19		860	880	80	>2.0	190	3.2	31.8	11.8	1165	*1	
J	20	800	890	915	120	2.3	80	2.3	38.1	3.9	1070	100	発明例
	21		900	930	115	2.7	70	2.0	34.0	9.5	2746	100	
	22		900	930	110	2.1	60	2.0	34.0	6.5	1879	100	
	23		900	925	110	2.4	60	2.3	31.8	8.2	1568	100	
	24		880	910	105	1.1	80	2.3	38.1	3.9	1070	*2	比較例
	25		860	910	110	2.1	70	2.0	34.0	6.5	1879	100	
	26		890	910	100	2.1	60	2.0	38.1	9.6	3484	100	
K	27	800	900	925	120	2.2	60	2.3	34.0	6.5	1420	100	発明例
	28		850	880	105	2.1	80	2.0	31.8	7.2	1820	100	
	29		860	880	105	1.3	80	2.0	34.0	6.5	1879	*2	比較例
	30		840	865	90	2.2	100	2.3	31.8	3.9	746	100	

*1：ベイナイト100%　*2：焼入れままマルテンサイト100%

[0080]
[A table 10]

鋼	番号	引張特性 TS (N/mm²)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	備考
G	7	1040	1900	発明例
	8	1210	1900	
	9	810	1900	比較例
	10	1120	950	
H	11	1410	2860	発明例
	12	1360	2860	
	13	1320	2860	
	14	870	2860	比較例
	15	1340	950	
I	16	1270	1900	発明例
	17	1360	1900	
	18	1420	950	比較例
	19	940	1900	
J	20	1480	1900	発明例
	21	1490	1900	
	22	1510	1900	
	23	1520	1900	
	24	1510	950	比較例
	25	1500	950	
	26	1570	950	
K	27	1480	2380	発明例
	28	1510	2380	
	29	1530	950	比較例
	30	1490	950	

[0081] For the electroseamed steel pipe which has hot-rolling conditions and tubulation conditions within the limits of this invention as shown in a table 10, tensile strength is 2 980Ns/mm. And high hydrogen crack generating marginal distortion deltaepsilonc of 1900 micrometers or more It is stabilized and obtained. Moreover, he was the complex tissue which consists of 80% or more of tempered martensite and a ferrite as systematically shown in a table 9. It is the hydrogen delay crack generating marginal addition distortion deltaepsilonc in that tensile strength runs short on the other hand by the sample of this invention with heat treatment conditions and tubulation conditions out of range ****. 950 micrometers and deltaepsilonc which was low and was stabilized A value was not acquired.
[0082] (Example 5) Seven sorts of steel of M-S shown in a table 11 was ingoted, and the electroseamed steel pipe of 31.8mmphix1.6mmt was produced by the approach shown in a table 12. It was before and after immersion, and the tension test was performed, and it asked [these steel pipes were immersed into 0.1N hydrochloric acid for 200 hours and] for the rate of retained strength, and considered as the index of endurance. In addition, it asked for the rate of retained strength (%) by the approach mentioned above. The result is shown in a table 13.
[0083]
[A table 11]

(wt.%)

鋼	C	Si	Mn	P	S	Al	Nb	Cu	Cr	Ni	Mo	Ti	B	N	
M	0.15	0.35	1.78	0.01	0.005	0.03	0.015	0.22	0.02	tr	tr	tr	tr	0.002	発明例
N	0.15	0.36	1.40	0.02	0.003	0.02	0.014	0.40	0.01	tr	tr	0.01	0.001	0.003	
O	0.17	0.41	1.80	0.01	0.003	0.03	0.020	0.16	0.01	tr	tr	tr	tr	0.004	
P	0.17	0.33	1.35	0.01	0.001	0.03	0.016	0.15	tr	tr	tr	0.01	0.001	0.002	
Q	0.17	0.41	1.82	0.01	0.002	0.03	tr	0.14	0.42	tr	tr	0.01	0.001	0.003	
R	0.17	0.40	1.50	0.01	0.003	0.03	tr	tr	0.03	tr	tr	tr	tr	0.003	比較例
S	0.23	0.37	1.90	0.01	0.002	0.03	tr	tr	0.03	tr	tr	tr	tr	0.003	

[0084]
[A table 12]

α	スラブ→熱延（インライン焼入れ焼戻し）→スリット→造管
β	スラブ→熱延→連続焼鈍（インライン焼入れ焼戻し）→スリット→造管
γ	スラブ→熱延→冷延→連続焼鈍（インライン焼入れ焼戻し）→スリット→造管
δ	スラブ→熱延→スリット→造管→焼入れ焼戻し
ε	スラブ→熱延→冷延→焼鈍→スリット→造管→焼入れ焼戻し

[0085]
[A table 13]

番号	鋼	製造方法	マルテンサイト分率 (%)	浸漬試験前のTS (N/mm²)	浸漬試験後のTS (N/mm²)	残留強度率 (%)	
1	M	α	80	1220	1040	85	発明例
2	M	γ	100	1420	1180	83	
3	M	δ	100	1400	1200	86	
4	N	α	80	1410	1300	92	
5	N	γ	100	1230	1110	90	
6	N	δ	100	1380	1210	88	
7	O	α	100	1530	1250	82	
8	O	γ	100	1520	1260	83	
9	O	δ	100	1470	1180	80	
10	O	ε	100	1550	1260	81	
11	P	α	100	1450	1190	82	
12	P	β	100	1520	1260	83	
13	P	γ	100	1550	1240	80	
14	P	δ	100	1540	1260	82	
15	Q	α	100	1560	1260	81	
16	Q	δ	100	1530	1250	82	
17	R	α	100	1380	990	72	比較例
18	R	β	100	1420	1040	73	
19	R	γ	100	1500	1110	74	
20	R	δ	100	1510	1120	74	
21	R	ε	100	1500	1080	72	
22	S	α	80	1320	920	70	
23	S	γ	100	1570	—	遅れ破壊割れ	
24	S	δ	100	1550	1010	65	

[0086] For the electroseamed steel pipe of the example of invention which fulfills the conditions specified by this invention in the steel presentation and the organization so that clearly from a table 13, tensile strength is 2 1180Ns/mm. It was above, and the rate of retained strength was high, and having the outstanding endurance was checked.

[0087]

[Effect of the Invention] Tensile strength 980N/mm2 which are used for autoparts, such as a door impact beam, a machine structural element, and an engineering-works structural member according to this invention as explained above The structural steel worker super-high tension electroseamed steel pipe excellent in the above hydrogen-proof delay crack property can be manufactured by low cost.

[Translation done.]

TECHNICAL FIELD

[The technical field to which invention belongs] This invention relates to the member for automobiles, the super-high tension electroseamed steel pipe further used for a machine structural element and an engineering-works structural member, and its manufacture approaches, such as a door impact beam.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The reinforcing materials called a door impact beam from a viewpoint of safety are prepared in the interior of car Doat, such as an automobile. Although the press cast of cold rolled high tensile strength steel sheets was used for the conventional door impact beam in many cases, tensile strength is 2 980Ns/mm because of recent years and lightweight-izing. The above remarkable high tension electroseamed steel pipe with high reinforcement is adopted increasingly.
[0003] About former and ultrahigh-tensile-strength-steel tubing, it is the steel which has the predetermined chemical entity currently indicated by each official report of JP,1-205032,A, JP,4-131327,A, JP,4-187319,A, JP,6-57375,A, JP,6-88129,A, and JP,6-179913,A the tensile strength of 980Ns/mm 2 After considering as the above high-tensile-steel plate, the method of carrying out electric resistance welding and obtaining a high intensity electroseamed steel pipe is proposed.
[0004] Moreover, hardening processing is performed to the steel pipe which has the predetermined chemical entity currently indicated by each official report of JP,3-122219,A and JP,4-63227,A, and it is 2 the tensile strength of 1180Ns/mm. The method of obtaining the above high tension electroseamed steel pipe is proposed.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Tensile strength 980N/mm2 which are used for autoparts, such as a door impact beam, a machine structural element, and an engineering-works structural member according to this invention as explained above The structural steel worker super-high tension electroseamed steel pipe excellent in the above hydrogen-proof delay crack property can be manufactured by low cost.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved] Since residual distortion exists with tubulation, consideration of as opposed to a hydrogen delay crack on the occasion of the practical use is required for the approach shown in each official report of above-mentioned JP,1-205032,A, JP,4-131327,A, JP,4-187319,A, JP,6-57375,A, JP,6-88129,A, and JP,6-179913,A etc.
[0006] However, the approach shown until now is not enough, even if the consideration to a hydrogen delay crack is not made, or it is and is released [are and], therefore need amplification of ultrahigh-tensile-strength-steel tubing is restricted.
[0007] On the other hand, although the approach shown in each official report of JP,3-122219,A and JP,4-63227,A does not have the residual distortion of ****, when corrosion progresses during the activity, it is a problem that shell reinforcement falls.
[0008] This invention is made in view of this situation, and its tensile strength is high, and or it excelled in the hydrogen-proof delay crack property, it aims at offering the super-high tension electroseamed steel pipe which was excellent also in corrosion resistance in addition to this, and its manufacture approach.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem] In order to attain said object, as a result of performing many experimental examination, or this invention persons were excellent in the hydrogen-proof delay crack property by rationalizing the heat treatment conditions and tubulation conditions of adjustment of a steel component, and a steel plate, and adjusting an organization, they acquired the knowledge of becoming possible to obtain the super-high tension electroseamed steel pipe which was excellent also in corrosion resistance in addition to this.
[0010] It is made based on such knowledge and this invention is [0011]. By weight %, C:0.10 - 0.19%, Si:0.01-0.5%, Mn: 0.8-2.2%, aluminum:0.01-0.06%, Cr:0.05-0.6%, It is Ar3 of said steel to the steel slab which consists of the remainder Fe and an unescapable impurity P:0.02% or less, S:0.003% or less, and N:0.005% or less. It is the temperature of the transformation point TAr3 When it carries out, It hot-rolls by controlling finishing temperature Tf so that finishing temperature Tf may become the temperature requirement of -(TAr 3+30) (TAr 3+100) **. In the case of the hot rolling, 30% or more of rolling reduction is given in the temperature requirement of Tf - (Tf+30) **. After cooling to the temperature Tc of a 150-250-degree C temperature requirement with the cooling rate of 60-200 degrees C/sec promptly after hot rolling, The manufacture approach of the super-high tension electroseamed steel pipe which is made to pile up in the temperature requirement below 150-degree-Cor more Tc 2 seconds or more, rolls round at the temperature of less than 150 degrees C, considers as hot rolled sheet steel, and is characterized by forming this hot rolled sheet steel by width-of-face contraction percentage Q which fills the following (1) types is offered.
[0012]
1000 <=Q/(t/D)2 <=3000 .... (1)
However, board thickness of a t(mm):steel plate, D (mm): The outer diameter of an electroseamed steel pipe and Q (%) are width-of-face contraction percentages, and are defined by the following formulas (2).
Q=[/pi(D-t)] x100 .... (2) [{width-of-face-pi (D-t) of a steel plate pi}]
[0013]
[Embodiment of the Invention] The super-high tension electroseamed steel pipe of this invention is begun and attained by controlling a component presentation and organization of steel. the 1st operation gestalt and the 2nd operation gestalt of this invention -- therefore, heat treatment conditions, tubulation conditions, etc. of a steel plate of a specific component presentation are specified, and the 3rd operation gestalt specifies a component presentation and the organization itself of steel.
[0014] Hereafter, each operation gestalt is explained to a detail.
(1) The 1st operation gestalt (chemical composition) tensile strength is 2 980Ns/mm. Above In order to acquire the outstanding hydrogen-proof delay crack property, and C:0.10 - 0.19%, Si: 0.01-0.5%, Mn:0.8-2.2%, aluminum:0.01-0.06%, Nb: Specify to the presentation restricted to less than [Ti:0.015%] including 0.005-0.03% and B:0.0005 - 0.0030% further P:0.02% or less, S:0.003% or less, and N:0.005% or less. Moreover, Cu:0.05-0.50% is added as a selection component. In that case, although nickel may be added, it may be less than [nickel:0.10%].
[0015] Hereafter, the reason for definition of each element is explained.

·C: C is an indispensable element, in order to make desired martensite generate and to secure target reinforcement. However, 980N/mm2 made into a target for a content to be less than 0.10% The above reinforcement is not obtained, but on the other hand, if a content exceeds 0.19%, tensile strength will become high too much, or the carbide size which deposits at the time of annealing will become large, and a hydrogen-proof delay crack property will deteriorate anyway. Therefore, the content of C is made into 0.10 - 0.19%.
[0016] Si: It is added in order that Si may secure the soundness of the electric-resistance-welding section, and since the content is demonstrated at 0.01 - 0.5%, the effectiveness makes the content of Si 0.01 - 0.5%.
[0017] Mn: Mn is an indispensable element, in order to raise the hardenability of an austenite, to make desired martensite generate and to secure target reinforcement. However, 980N/mm2 made into a target for a content to be less than 0.8% The above reinforcement is not obtained, but on the other hand, if a content exceeds 2.2%, a hydrogen-proof delay crack property will deteriorate. Therefore, the content of Mn is made into 0.8 - 2.2%.
[0018] aluminum: aluminum fixes as AlN N which is added as a deoxidation element and exists as an impurity in steel, and raises a hydrogen-proof delay crack property. However, if it is few at less than 0.01% and, as for the addition effectiveness, exceeds 0.06% on the other hand, inclusion will increase and a hydrogen-proof delay crack property will deteriorate. Therefore, the content of aluminum is made into 0.01 - 0.06%.
[0019] Nb : Nb is an element which controls the austenite grain growth at the time of heating in a continuous annealing furnace, makes martensitic structure detailed, and raises a hydrogen-proof delay crack property. The addition effectiveness is accepted at 0.005% or more, and on the other hand, even if it adds exceeding 0.02%, the addition effectiveness is saturated. Therefore, the content of Nb is made into 0.005 - 0.02%.
[0020] B: B is an element required in order to make desired martensite generate and to secure target reinforcement. However, 980N/mm2 made into a target for an addition to be less than 0.0005% The above reinforcement is not obtained, but on the other hand, even if an addition exceeds 0.0030%, the addition effectiveness is saturated. Therefore, the content of B is made into 0.0005 - 0.0030%.
[0021] P: P needs to regulate to 0.02% or less in order to degrade a delayed fracture-proof property.
S: In order for S to exist as inclusion and to degrade a hydrogen-proof delay crack property, to regulate to 0.003% or less is required.
[0022] N: Since a hydrogen-proof delay crack property will fall if N is contained exceeding 0.005%, the need has regulated to 0.005% or less.
Ti: If Ti deposits as a big and rough nitride, since it will reduce a hydrogen-proof delay crack property, not adding is desirable. However, Dissolution N is fixed as TiN, and in order to secure the hardenability of B, to add reluctantly, it is necessary to make the addition into 0.015% or less.

[0023] Cu : Cu is an element which controls progress of the corrosion of a steel pipe, and controls trespass of the hydrogen to the inside of a steel pipe, and raises a hydrogen-proof delay crack property. The addition effectiveness is accepted at 0.05% or more, and the addition effectiveness is saturated even if it adds exceeding 0.50% on the other hand. Therefore, in adding Cu, it makes the content into 0.05 - 0.50%.
[0024] The relation between Cu addition and the variation of crack generating marginal addition distortion (deltaepsilon) is shown in drawing 1 . It is understood that crack generating marginal addition distortion (deltaepsilon) increases, and a hydrogen delay crack is controlled by Cu addition from this drawing.
[0025] nickel: As for nickel, it is desirable not to add in order to promote local corrosion and to reduce a hydrogen-proof delay crack property by the casting segregation. However, in order to avoid Cu crack at the time of hot-rolling, in adding reluctantly, lowering of a hydrogen-proof delay crack property makes a content 0.10% or less which is not remarkable.
[0026] The relation between nickel addition and the variation of crack generating marginal addition distortion (deltaepsilon) is shown in drawing 2 . It is understood that crack generating

marginal addition distortion (deltaepsilon) decreases, and a hydrogen delay crack is promoted by nickel addition from this drawing.
[0027] After carrying out soak of the steel slab of the above-mentioned chemical composition at 1150-1300 degrees C, (Manufacture conditions) It is Ar3 to this slab. The hot rolling which makes beyond a point finishing temperature is performed. It rolls round at 500-650 degrees C, and considers as a hot-rolling steel strip. This hot rolled sheet steel After the acid-washing cold press, It quenches after soak heating at 800-900 degrees C with a continuous annealing furnace, and tempering processing is performed at further 150-250 degrees C, and the obtained steel plate is formed by width-of-face contraction percentage Q which fills the following (1) types, and it considers as a 80 - 100% tempered martensite + remainder ferrite.
[0028] A. Whenever [hot rolling condition a. slab stoving temperature], whenever [slab stoving temperature] needs to be 1150 degrees C or more, in order to make Nb dissolve. If whenever [slab stoving temperature] does not fulfill 1150 degrees C, it is solute drug with sufficient Nb at the time of heating in a continuous annealing furnace. In order not to demonstrate effectiveness, martensitic structure does not become detailed and the improvement effectiveness of the hydrogen-proof delay crack property by Nb addition is not acquired. On the other hand, the upper limit of whenever [slab stoving temperature] is made into 1300 degrees C from an operable viewpoint.
[0029] b. Finish rolling temperature finish rolling temperature is Ar3. It is necessary to be beyond a point. Finish rolling temperature is Ar3. It is solute drug with sufficient Nb at the time of heating [in / that it is below a point / by distorted induction deposit of Nb carbon nitride in the ferrite transformation section / a continuous annealing furnace]. In order not to demonstrate effectiveness, martensitic structure does not become detailed and the improvement effectiveness of the hydrogen-proof delay crack property by Nb addition is not acquired.
[0030] c. Make winding temperature winding temperature into 500-650 degrees C. If winding temperature exceeds 650 degrees C, Nb carbide will make it big and rough, and it does not re-dissolve at the time of heating in a continuous annealing furnace, but is sufficient solute drug. In order not to demonstrate effectiveness, martensitic structure does not become detailed and the improvement effectiveness of the hydrogen-proof delay crack property by Nb addition is not acquired. On the other hand, a hot-rolling steel strip makes it hard that winding temperature is less than 500 degrees C, and it becomes an operation top problem.
[0031] B. Make whenever [in a continuous annealing furnace / stoving temperature] into 800-900 degrees C whenever [in a continuous annealing furnace / heat treatment condition a. stoving temperature]. The amount of martensite of amount sufficient after quenching at less than 800 degrees C is not obtained, and target reinforcement is not obtained. On the other hand, if 900 degrees C is exceeded, detailed martensitic structure will not be obtained by austenite grain big and rough-ization at the time of heating, but a hydrogen-proof delay crack property will fall.
[0032] b. The steel strip made into the 80 - 100% martensite + remainder ferrite obtained by tempering heat treatment condition heating-quenching performs tempering processing in a 150-250-degree C temperature requirement. In the tempering temperature of less than 150 degrees C, martensitic transformation distortion remains and the hydrogen-proof crack nature after tubulation falls. On the other hand, if tempering temperature exceeds 250 degrees C, the cementite phase which deposits with annealing will become big and rough, and a delayed fracture-proof property will fall.
[0033] C. Width-of-face drawing in the tubulation process of tubulation condition electric-resistance-welding-sizing is the important requirements for cheating out of the hydrogen-proof delay crack property of a steel pipe good, and after for that controlling width-of-face contraction percentage Q within limits shown by (1) formula, it forms a tube.
[0034]
1000 <=Q/(t/D)2 <=3000 .... (1)
However, board thickness of a t(mm):steel plate, D (mm): The outer diameter of an electroseamed steel pipe and Q (%) are width-of-face contraction percentages, and are defined by the following formulas (2).

Q=[/pi(D-t)] x100 .... (2) [{width-of-face-pi (D-t) of a steel plate pi}]
It is Q/2 (t/D) to drawing 3 . Hydrogen delay crack generating marginal addition distortion deltaepsilonc Relation is shown. As a result of this invention persons' performing many experimental examination about tubulation conditions and a hydrogen-proof delay crack property, as shown in drawing 3 , for the hydrogen delay crack generating marginal addition distortion of a steel pipe, width-of-face contraction percentage Q is 1000(t/D) 2 -3000(t/D) 2. It had a peak in between and found out that the steel pipe which has the hydrogen-proof delay crack property excellent in controlling a width-of-face contraction percentage in this range was obtained. This proper width-of-face contraction percentage is a product (board thickness/outer diameter). In order to obtain the steel pipe which changes with ratios and has the outstanding hydrogen-proof delay crack property (board thickness/outer diameter) It is necessary to take a different width-of-face contraction percentage for every ratio.
[0035] The hydrogen-proof delay crack property of a steel pipe is width-of-face contraction percentage Q=1000(t/D) 2 -3000(t/D) 2. The reason for having a peak in between is considered as follows. That is, a width-of-face contraction percentage is 1000(t/D) 2. In not filling, the maximum residual distortion of a steel pipe increases, the hydrogen-proof delay crack property of a steel pipe deteriorates, and a width-of-face contraction percentage is 3000(t/D) 2 to reverse. In exceeding, tubulation rolling texture is formed with tubulation, the hydrogen-proof delay crack sensitivity of a steel pipe increases, and the hydrogen-proof delay crack property of a steel pipe deteriorates.
[0036] In addition, hydrogen delay crack generating marginal addition distortion deltaepsilonc After cutting down C-ring test piece with a width of face of 20mm, performing bolting to the outer diameter before logging and adding distortion of the residual distortion of a steel pipe from an electroseamed steel pipe, the addition distortion of the limitation which the crack at the time of adding addition distortion (deltaepsilon) further calculate by the following (3) formulas, being immerse into 0.1-N hydrochloric acid for 200 hours, and investigating crack generating existence generate be point out. Let this value be the index of a hydrogen-proof delay crack property. Namely, for a hydrogen-proof delay crack property, it is so desirable that this value is high.
[0037]
deltaepsilon=(4, 106, and t-delta)/(pi-D- (D-t)) .... (3)
Here, t is [the outer diameter of the steel pipe before logging and delta of board thickness and D] D- (outer diameter after addition distortion addition).
[0038] Tensile strength 980N/mm2 which were excellent in the hydrogen-proof delay crack property by forming a 80 - 100% tempered martensite + remainder ferrite by the above approaches The above electroseamed steel pipe is manufactured.
[0039] (2) The 2nd operation gestalt (chemical composition) tensile strength is 2 980Ns/mm. Above In order to acquire the outstanding hydrogen-proof delay crack property, by weight % And C:0.10 - 0.19%, Si: Specify to the presentation restricted to P:0.02% or less, S:0.003% or less, and N:0.005% or less including 0.01-0.5%, Mn:0.8-2.2%, aluminum:0.01-0.06%, and Cr:0.05-0.6%. Moreover, Nb:0.005-0.03% and V:0.005 - 0.03% of inside [at least one sort, B:0.0005 - 0.0030%, and Cu:0.05-0.50% of] is added as a selection component. Moreover, although nickel may be added when Cu is added, it may be less than [nickel:0.30%].
[0040] Hereafter, the reason for definition of each element is explained. The reason for definition of C, Si, Mn, and aluminum is the same as the above-mentioned 1st operation gestalt.
Cr : It is an element for securing raising and target reinforcement by the interaction with Mn. [hardenability / of steel] If the effectiveness is scarce in the content being less than 0.05% and it exceeds 0.6% on the other hand, a hydrogen-proof delay crack property will deteriorate. Therefore, the content of Cr is made into 0.05 - 0.6%.
[0041] About P, S, and N, it is restricted to the above-mentioned range by the same reason as the 1st operation gestalt.
Nb, V : Since each of Nb(s) and V can make the austenite grain before a transformation detailed and the martensite packet after a transformation can be made detailed, it is an element desirable to improvement in a hydrogen-proof delay crack property. However, at less than 0.005%, if there is little the effectiveness and it adds exceeding 0.03% on the other hand, a hydrogen-proof delay

crack property will deteriorate on the contrary, respectively. Therefore, the content of Nb and V is made into 0.005 - 0.03%, respectively.

[0042] B: B makes desired martensite generate, and in order to secure target reinforcement, it is added if needed. However, 980N/mm2 made into a target for an addition to be less than 0.0005% The above reinforcement is not obtained, but the addition effectiveness is saturated even if an addition exceeds 0.0030% on the other hand. Therefore, in adding the content of B, it may be 0.0005 - 0.0030%.

[0043] In adding by the same reason as ** and the 1st operation gestalt just to Cu, it considers as 0.05 - 0.50% of range. If the amount of Cu(s) is increased, the surface discontinuity called Cu crack depending on the case may occur, this can be prevented by nickel addition, but since nickel is an element harmful for a hydrogen-proof delay crack property, it is desirable to restrict the addition to 0.3% or less.

[0044] (Manufacture conditions) the steel slab of the above-mentioned presentation — receiving — Ar3 of the steel the temperature of the transformation point — TAr3 **, when it carries out It hot-rolls by controlling finishing temperature Tf so that finishing temperature Tf may become the temperature requirement of -(TAr 3+30) (TAr 3+100) **. In the case of the hot rolling, 30% or more of rolling reduction is given in the temperature requirement of Tf - (Tf+30) **. After cooling to the temperature Tc of a 150-250-degree C temperature requirement with the cooling rate of 60-200 degrees C/sec promptly after hot rolling, It is made to pile up in the temperature requirement below 150-degree-Cor more Tc 2 seconds or more, and it rolls round at the temperature of less than 150 degrees C, and considers as hot rolled sheet steel, and this hot rolled sheet steel is formed by width-of-face contraction percentage Q which fills the above-mentioned (1) formula.

[0045] A. Hot-rolling condition a. finishing-temperature finishing temperature Tf is taken as the temperature requirement of -(TAr 3+30) (TAr 3+100) **. It is 2 that finishing temperature is under ** (TAr 3+30) 980Ns/mm. The rate of the volume of the martensite for obtaining the above reinforcement is not obtained. On the other hand, if ** (TAr 3+100) is exceeded, a martensite packet will make it big and rough, and a hydrogen-proof delay crack property will fall.

[0046] b. In order to make pressing-down condition martensite detailed and to make a hydrogen-proof delay crack property good, the bottom of the pressure in front of hot rolling termination is required. For this reason, it hot-rolls by giving 30% or more of rolling reduction in the temperature requirement of Tf - (Tf+30) **.

[0047] B. Quench to Tc of a 150-250-degree C temperature requirement with the cooling rate of 60-200 degrees C/sec promptly after the cooling condition hot rolling after hot rolling. Thereby, it is 2 980Ns/mm. The rate of the martensite volume for obtaining the above reinforcement is securable. The martensite of the rate of the volume of the request by cooling rates being under 60 degrees C / sec cannot be obtained. Moreover, if a cooling rate exceeds 200 degrees C/sec, the trouble on operation will be produced. If higher about cooling-shut-down temperature than 250 degrees C, the martensite of the desired rate of the volume will not be obtained.

[0048] Thus, after quenching, it is made to pile up in the temperature requirement below 150-degree-Cor more Tc 2 seconds or more. Thereby, hard tempered martensite is generated. The relation between the holding time when holding the steel plate which drawing 4 quenched in a 150-250-degree C temperature requirement, and hydrogen delay crack generating marginal addition distortion deltaepsilon is shown. From this drawing, it is stabilized by maintenance for 2 seconds or more, and is the high hydrogen delay crack generating marginal addition distortion deltaepsilonc near 2000 micrometers. It turns out that it is obtained. Since hardening distortion remains in less than 2 seconds, it is high deltaepsilonc 1900 micrometers or more. It cannot stabilize and obtain.

[0049] C. Perform winding temperature winding at the temperature of less than 150 degrees C. This temperature does not serve as a hard tempering martensitic phase above 150 degrees C, but it is 2 980Ns/mm. The above reinforcement is not obtained.

[0050] D. tubulation conditions — although a tube is formed to a super-high tension electroseamed steel pipe using the hot rolled sheet steel manufactured on the above conditions, it is necessary to fill the above-mentioned (1) formula like the above-mentioned 1st operation

gestalt in that case

[0051] (3) The 3rd operation gestalt (chemical composition and organization) tensile strength is 2 980Ns/mm. It is above, and in order to acquire the hydrogen-proof delay crack nature and corrosion resistance which were moreover excellent, it has the presentation containing C:0.13 - 0.19%, Mn:1.0-2.0%, and Cu:0.05-0.50%, and considers as 80 - 100% of martensite or the tempering martensitic structure obtained by hardening heat treatment. Moreover, when adding nickel and Mo, it is restricted to less than [nickel:0.1%] and less than [Mo:0.3%].

[0052] Hereafter, the reason for definition of each element is explained.

C: C is an indispensable element, in order to make desired martensite generate and to secure target reinforcement. However, 1180N/mm2 made into a target for a content to be less than 0.13% The above reinforcement is not obtained, but on the other hand, if a content exceeds 0.19%, the shell lowering on the strength by the hydrogen delay crack or corrosion will be promoted, and endurance will deteriorate. Therefore, the content of C is made into 0.13 - 0.19%.

[0053] Mn: Mn is an indispensable element, in order to make desired martensite generate and to secure target reinforcement. However, 1180N/mm2 made into a target for a content to be less than 1.0% The above reinforcement is not obtained but, on the other hand, the hydrogen-proof delay crack to which a content exceeds 2.0%, or a corrosion property deteriorates. Therefore, the content of Mn is made into 1.0 - 2.0%.

[0054] Cu : Cu is an element which lowers the hydrogen delay crack sensitivity of a steel pipe, controls progress of the shell lowering on the strength by corrosion further, and raises the endurance of a super-high tension electroseamed steel pipe. The addition effectiveness is accepted at 0.05% or more, and the addition effectiveness is saturated even if it adds exceeding 0.50% on the other hand. Therefore, in adding Cu, it makes the content into 0.05 - 0.50%.

[0055] The relation between Cu addition and the rate of retained strength after a corrosion test is shown in drawing 5 . The rate of retained strength increases by Cu addition from this drawing, and it is understood that the endurance of a steel pipe increases. In addition, the rate of retained strength can be expressed with the following formulas.

[0056] rate (%) of retained strength ={TS(N/mm2) before TS (N/mm2)/immersion test after immersion test} x100 -- here -- the tubing cross section (mm2) before the **** (breaking load N) / immersion test before TS(N/mm2) = immersion test before an immersion test

The tubing cross section before the **** (breaking load N) / immersion test after TS(N/mm2) = immersion test after an immersion test (mm2)

It comes out.

[0057] nickel: As for nickel, it is desirable not to add in order to promote local corrosion and to reduce a hydrogen-proof delay crack property by the casting segregation. However, in order to avoid Cu crack at the time of hot-rolling, in adding reluctantly, decline in the rate of retained strength makes a content 0.10% or less which is not remarkable.

[0058] Mo: As for Mo, it is desirable not to add in order to promote local corrosion and to reduce a hydrogen-proof delay crack property by the casting segregation. However, in order to secure hardenability, in adding reluctantly, decline in the rate of retained strength makes a content 0.30% or less which is not remarkable.

[0059] The relation between nickel addition and the retained strength after a corrosion test is shown in drawing 6 , and the relation between Mo addition and the rate of retained strength after a corrosion test is shown in drawing 7 . The rate of retained strength decreases from these drawings by addition of 0.1% or less of nickel, and 0.3% or less of Mo, and it is understood that the endurance of a steel pipe falls.

[0060] No elements other than these doing especially big effect to the endurance of a steel pipe, i.e., hydrogen-proof delay crack nature, and corrosion resistance, therefore usually carrying out amount proper addition of the alloy alloying elements, such as Si, P, aluminum, Nb, B, Ti, and Cr, according to other objects is permitted.

[0061] Hardening heat treatment of the steel which has the above presentation is carried out, and it considers as 80 - 100% of martensite, or tempering martensitic structure. By considering as above presentations and organizations, it is 2 the tensile strength of 980Ns/mm. Above, the super-high tension electroseamed steel pipe excellent in endurance, i.e., hydrogen-proof delay

crack nature, and corrosion resistance is obtained.
[0062] (Manufacture conditions) If it faces manufacturing the electroseamed steel pipe concerning this 3rd operation gestalt and 80 - 100% of martensite or tempering martensitic structure is obtained by hardening heat treatment, that manufacture approach is not limited but can also be manufactured on the manufacture conditions of the above-mentioned 1st operation gestalt and the 2nd operation gestalt.

[Translation done.]

* NOTICES *

EXAMPLE

[Example] Hereafter, the example of this invention is explained.
(Example 1) Six sorts of steel of A-F shown in a table 1 was ingoted, and the electroseamed steel pipe of 31.8mmphix1.6mmt was produced on the hot-rolling conditions specified by this invention as shown in a table 2, the heat treatment conditions in a continuous annealing furnace, and tubulation conditions.
[0064] While measuring the tensile strength of these steel pipes, and three-point bending maximum load, the hydrogen-proof delay cracking test was carried out. The three-point bending test was performed by push metallic-ornaments radius =152mm and support span =600mm. a hydrogen-proof delay cracking test add addition distortion (deltaepsilon) further calculate by the above-mentioned (3) formula after cut down C-ring test piece with a width of face of 20mm, perform bolting to the outer diameter before logging and add distortion of the residual distortion of a steel pipe from a steel pipe, and be 200 in 0.1-N hydrochloric acid. time amount immersion be carried out, crack generating existence be investigated and crack generating marginal addition distortion be made into the index of a hydrogen-proof delay crack property. A result is shown in a table 3.
[0065]
[A table 1]

鋼	化学成分 (wt%)													
	C	Si	Mn	P	S	Al	Nb	Cu	Ni	Ti	B	N		
A	0.12	0.38	1.40	0.01	0.001	0.03	0.015	tr	tr	0.011	0.0008	0.003	790	発明材
B	0.15	0.42	1.01	0.01	0.003	0.04	0.012	tr	tr	0.009	0.0012	0.003	780	
C	0.17	0.39	1.33	0.01	0.002	0.03	0.015	0.33	tr	tr	0.0018	0.002	760	
D	0.17	0.40	1.40	0.01	0.002	0.03	0.013	tr	tr	0.008	0.0012	0.003	760	
E	0.17	0.41	1.35	0.01	0.001	0.03	0.013	0.20	tr	0.010	0.0011	0.003	760	
F	0.23	0.41	1.90	0.01	0.002	0.03	tr	tr	tr	tr	tr	0.004	750	比較材

[0066]
[A table 2]

鋼	番号	Ar3 (℃)	熱延条件 加熱温度 (℃)	熱延条件 仕上温度 (℃)	熱延条件 巻取温度 (℃)	連続焼鈍炉熱処理条件 加熱温度 (℃)	連続焼鈍炉熱処理条件 焼戻し温度 (℃)	造管条件 板厚 t (mm)	造管条件 外径 D (mm)	造管条件 縮率 Q (%)	造管条件 Q/(t/D)²	ミクロ組織 マルテンサイト分率 (%)	
A	1	790	1240	830	630	890	200	1.6	31.8	4.9	1940	100	発明例
B	2	780	1230	860	620	860	190	1.6	31.8	4.9	1940	100	
C	3	760	1200	870	610	840	220	1.6	31.8	4.9	1940	100	
D	4	760	1180	850	590	850	220	1.6	31.8	4.9	1940	100	
E	5	760	1210	860	580	870	210	1.6	31.8	4.9	1940	100	
F	6	750	1250	860	610	880	220	1.6	31.8	4.9	1940	100	比較例

[0067]
[A table 3]

鋼	番号	引張特性 TS (MPa)	三点曲げ特性 最大荷重 (kW)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	
A	1	1210	12.1	2140	発明例
B	2	1380	14.0	2140	
C	3	1490	14.8	3330	
D	4	1510	15.6	2140	
E	5	1500	15.5	3100	
F	6	1720	17.5	0	比較例

[0068] Steel A-E which satisfies the presentation specified by this invention had a high crack generating marginal distortion compared with the comparison steel F, and it was checked that the outstanding hydrogen-proof delay crack property is shown so that I might be understood from a table 3.
[0069] (Example 2) Hot-rolling conditions as shown in a table 4 using above mentioned steel A-E, the heat treatment conditions in a continuous annealing furnace, and tubulation conditions (board thickness/outer diameter), Various ratios were changed and the tube was formed to the electroseamed steel pipe. These mechanical characteristics and a hydrogen-proof delay cracking test result are shown in a table 5.
[0070]
[A table 4]

鋼	番号	Ar3 (℃)	熱延条件 加熱温度 (℃)	熱延条件 仕上温度 (℃)	熱延条件 巻取温度 (℃)	連続焼鈍炉熱処理条件 加熱温度 (℃)	連続焼鈍炉熱処理条件 焼戻し温度 (℃)	造管条件 板厚 t (mm)	造管条件 外径 D (mm)	造管条件 縮径率 Q (%)	造管条件 $Q/(t/D)^2$	ミクロ組織 マルテンサイト分率 (%)	
A	7	790	1200	860	520	880	220	2.0	31.8	6.0	1520	100	発明例
	8		1160	850	580	890	240	2.0	31.8	6.0	1520	100	
	9		1230	860	670	880	220	2.0	31.8	6.0	1520	100	比較例
	10		1220	840	590	890	180	2.0	31.8	2.0	510	100	
B	11	780	1210	830	600	810	210	1.6	38.1	2.0	1130	90	発明例
	12		1170	850	600	870	230	1.8	31.8	4.8	1500	100	
	13		1180	820	590	860	180	2.0	31.8	8.2	2070	100	
	14		1120	830	600	860	190	2.0	31.8	8.2	2070	100	比較例
	15		1280	750	620	880	200	2.0	31.8	6.0	1520	100	
C	16	760	1220	830	580	860	200	1.6	31.8	4.8	1900	100	発明例
	17		1250	820	570	840	220	2.0	31.8	9.0	2280	100	
	18		1250	830	550	760	210	1.6	31.8	4.8	1900	100	比較例
	19		1240	860	560	850	190	2.0	38.1	9.0	3270	100	
D	20	760	1250	840	610	860	210	1.6	31.8	3.2	1260	100	発明例
	21		1230	880	600	870	210	2.0	31.8	6.0	1520	100	
	22		1180	870	600	940	230	1.6	31.8	3.2	1260	100	比較例
	23		1190	830	540	850	340	2.0	31.8	6.0	1520	100	
E	24	760	1210	850	580	860	200	1.6	38.1	5.2	2950	100	発明例
	25		1210	840	560	880	200	1.8	31.8	6.0	1870	100	
	26		1230	850	620	870	230	2.0	38.1	2.8	1020	100	
	27		1210	880	630	860	220	2.0	31.8	5.2	1310	100	
	28		1240	860	590	870	20	1.6	31.8	2.8	1110	100	比較例
	29		1200	860	590	860	200	1.8	31.8	9.8	3060	100	
	30		1190	840	550	850	230	2.0	31.8	2.8	710	100	

[0071]
[A table 5]

鋼	番号	引張特性 TS (MPa)	三点曲げ特性 最大荷重 (kW)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	
A	7	1220	11.0	2140	発明例
	8	1280	13.6	2140	
	9	1180	12.9	950	比較例
	10	1240	9.8	950	
B	11	1060	17.0	2380	発明例
	12	1290	14.7	2140	
	13	1350	16.8	2140	
	14	1320	14.2	950	比較例
	15	1390	16.6	950	
C	16	1480	22.1	3330	発明例
	17	1420	17.3	3330	
	18	890	24.3	3330	比較例
	19	1510	17.9	950	
D	20	1520	22.1	2140	発明例
	21	1490	17.3	2140	
	22	1480	24.3	950	比較例
	23	1500	17.9	950	
E	24	1530	15.4	3100	発明例
	25	1510	15.1	3100	
	26	1470	16.4	3100	
	27	1480	16.9	3100	
	28	1430	18.4	950	比較例
	29	1410	17.6	480	
	30	1500	18.2	950	

[0072] For the electroseamed steel pipe of an example which fulfills the conditions which hot-rolling conditions, the heat treatment conditions in a continuous annealing furnace, and tubulation conditions specified by this invention so that I may be understood from a table 5, tensile strength is 2 980Ns/mm. It was above, and crack generating marginal distortion was high and having the outstanding hydrogen-proof delay crack property was checked.
[0073] (Example 3) Six sorts of steel of G-L shown in a table 6 was ingoted, and the electroseamed steel pipe of 34.8mmphix2.3mmt was produced on the hot-rolling conditions and tubulation conditions which were specified by this invention as shown in a table 7. And hydrogen delay crack generating marginal addition distortion deltaepsilonc which is the index of the tensile strength of these steel pipes, and a hydrogen-proof crack property It measured. A result is shown in a table 8.
[0074]
[A table 6]

鋼	化学成分 (wt%)												備考
	C	Si	Mn	P	S	Al	Cr	Cu	Ni	Nb	V	N	
G	0.12	0.42	1.90	0.01	0.002	0.03	0.47	0.02	0.01	0.000	0.000	0.003	発明材
H	0.15	0.41	1.51	0.01	0.003	0.04	0.42	0.30	0.02	0.000	0.000	0.003	
I	0.15	0.40	1.80	0.01	0.002	0.03	0.46	0.01	0.01	0.010	0.000	0.004	
J	0.18	0.38	1.79	0.01	0.002	0.03	0.46	0.01	0.01	0.000	0.000	0.003	
L	0.18	0.41	1.81	0.01	0.001	0.03	0.44	0.22	0.01	0.000	0.000	0.003	
K	0.23	0.40	1.82	0.01	0.002	0.03	0.02	0.01	0.02	0.000	0.000	0.003	比較材

[0075]
[A table 7]

鋼	番号	Ar3温度 (℃)	熱延条件					造管条件				組織	備考
			仕上温度 (℃)	30%圧下温度 (℃)	冷却速度 ℃/s	保持時間 (s)	巻取温度 (℃)	板厚 t (mm)	外径 D (mm)	幅絞り率 Q (%)	$Q/(t/D)^2$	焼戻しマルテンサイト分率 (%)	
G	1	820	900	925	130	2.5	80	2.3	34.0	6.5	1420	100	発明例
H	2	810	910	940	120	2.3	70	2.3	34.0	6.5	1420	100	
I	3	810	880	905	125	2.8	60	2.3	34.0	6.5	1420	100	
J	4	800	890	915	110	2.2	70	2.3	34.0	6.5	1420	100	
K	5	800	870	890	115	2.3	50	2.3	34.0	6.5	1420	100	
L	6	790	890	910	120	2.1	50	2.3	34.0	6.5	1420	100	比較例

[0076]
[A table 8]

鋼	番号	引張特性 TS (N/mm²)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	備考
A	1	1180	1900	発明例
B	2	1360	2860	
C	3	1390	1900	
D	4	1480	1900	
E	5	1500	2380	
F	6	1640	0	比較例

[0077] Each steel G-J which satisfies the presentation specified by this invention as shown in a table 8 is 2 980Ns/mm. The above reinforcement is shown and it is the high hydrogen delay crack generating marginal addition distortion deltaepsilonc of 1900 micrometers or more. It was stabilized and obtained. Moreover, as systematically shown in a table 7, it was 100% tempered martensite. On the other hand, for the steel L which separates from the range which the amount of C specifies by this invention, the problem on reinforcement is the hydrogen delay crack generating marginal addition distortion deltaepsilonc, although there is nothing. It was remarkably low and it was checked that a hydrogen-proof delay crack property is inferior.
[0078] (Example 4) Hydrogen delay crack generating marginal addition distortion deltaepsilonc which various hot-rolling conditions and tubulation conditions are changed, a **** steel plate is produced as shown in a table 9 using steel G-L of a table 6, and is the index of the tensile strength of these steel pipes, and a hydrogen-proof crack property It measured. A result is shown in a table 10.
[0079]
[A table 9]

鋼	番号	Ar3温度 (℃)	熱延条件 仕上温度 (℃)	30%圧下温度 (℃)	冷却速度 ℃/s	保持時間 (s)	巻取温度 (℃)	造管条件 板厚 t (mm)	外径 D (mm)	幅絞り率 Q (%)	$Q/(t/D)^2$	組織 焼戻しマルテンサイト分率 (%)	備考
G	7	820	850	870	90	2.3	70	2.3	38.1	3.9	1070	85	発明例
	8		890	915	120	2.7	80	2.3	31.8	8.2	1568	100	
	9		900	920	50	2.5	60	2.3	38.1	3.9	1070	60	比較例
	10		920	940	120	2.5	70	2.3	31.8	4.8	918	100	
H	11	810	860	890	90	2.2	80	3.2	31.8	11.8	1165	100	発明例
	12		850	875	125	2.0	90	2.3	34.0	10.5	2295	100	
	13		850	870	95	2.1	60	3.2	38.1	7.5	1063	100	
	14		810	830	90	2.3	100	2.3	38.1	3.9	1070	60	比較例
	15		940	955	130	2.7	60	2.3	31.8	8.2	1568	100	
I	16	810	860	880	120	3.2	70	2.3	38.1	3.9	1070	100	発明例
	17		880	900	85	2.0	60	3.2	31.8	11.8	1165	100	
	18		890	910	105	2.1	90	2.3	38.1	11.8	3238	100	比較例
	19		860	880	80	>2.0	190	3.2	31.8	11.8	1165	*1	
J	20	800	890	915	120	2.3	80	2.3	38.1	3.9	1070	100	発明例
	21		900	930	115	2.7	70	2.0	34.0	9.5	2746	100	
	22		900	930	110	2.1	60	2.0	34.0	6.5	1879	100	
	23		900	925	110	2.4	60	2.3	31.8	8.2	1568	100	
	24		880	910	105	1.1	80	2.3	38.1	3.9	1070	*2	比較例
	25		860	910	110	2.1	70	2.0	34.0	6.5	1879	100	
	26		890	910	100	2.1	60	2.0	38.1	9.6	3484	100	
K	27	800	900	925	120	2.2	60	2.3	34.0	6.5	1420	100	発明例
	28		850	880	105	2.1	80	2.0	31.8	7.2	1820	100	
	29		860	880	105	1.3	80	2.0	34.0	6.5	1879	*2	比較例
	30		840	865	90	2.2	100	2.3	31.8	3.9	746	100	

*1：ベイナイト１００%　　*2：焼入れままマルテンサイト１００%

[0080]
[A table 10]

鋼	番号	引張特性 TS (N/mm²)	耐水素遅れ割れ特性 割れ発生限界付加歪み、Δε (μ)	備考
G	7	1040	1900	発明例
	8	1210	1900	
	9	810	1900	比較例
	10	1120	950	
H	11	1410	2860	発明例
	12	1360	2860	
	13	1320	2860	
	14	870	2860	比較例
	15	1340	950	
I	16	1270	1900	発明例
	17	1360	1900	
	18	1420	950	比較例
	19	940	1900	
J	20	1480	1900	発明例
	21	1490	1900	
	22	1510	1900	
	23	1520	1900	
	24	1510	950	比較例
	25	1500	950	
	26	1570	950	
K	27	1480	2380	発明例
	28	1510	2380	
	29	1530	950	比較例
	30	1490	950	

[0081] For the electroseamed steel pipe which has hot-rolling conditions and tubulation conditions within the limits of this invention as shown in a table 10, tensile strength is 2 980Ns/mm. And high hydrogen crack generating marginal distortion deltaepsilonc of 1900 micrometers or more It is stabilized and obtained. Moreover, he was the complex tissue which consists of 80% or more of tempered martensite and a ferrite as systematically shown in a table 9. It is the hydrogen delay crack generating marginal addition distortion deltaepsilonc in that tensile strength runs short on the other hand by the sample of this invention with heat treatment conditions and tubulation conditions out of range ****. 950 micrometers and deltaepsilonc which was low and was stabilized A value was not acquired.
[0082] (Example 5) Seven sorts of steel of M-S shown in a table 11 was ingoted, and the electroseamed steel pipe of 31.8mmphix1.6mmt was produced by the approach shown in a table 12. It was before and after immersion, and the tension test was performed, and it asked [these steel pipes were immersed into 0.1N hydrochloric acid for 200 hours and] for the rate of retained strength, and considered as the index of endurance. In addition, it asked for the rate of retained strength (%) by the approach mentioned above. The result is shown in a table 13.
[0083]
[A table 11]

(wt.%)

鋼	C	Si	Mn	P	S	Al	Nb	Cu	Cr	Ni	Mo	Ti	B	N	
M	0.15	0.35	1.78	0.01	0.005	0.03	0.015	0.22	0.02	tr	tr	tr	tr	0.002	発明例
N	0.15	0.36	1.40	0.02	0.003	0.02	0.014	0.40	0.01	tr	tr	0.01	0.001	0.003	
O	0.17	0.41	1.80	0.01	0.003	0.03	0.020	0.16	0.01	tr	tr	tr	tr	0.004	
P	0.17	0.33	1.35	0.01	0.001	0.03	0.016	0.15	tr	tr	tr	0.01	0.001	0.002	
Q	0.17	0.41	1.82	0.01	0.002	0.03	tr	0.14	0.42	tr	tr	0.01	0.001	0.003	
R	0.17	0.40	1.50	0.01	0.003	0.03	tr	tr	0.03	tr	tr	tr	tr	0.003	比較例
S	0.23	0.37	1.90	0.01	0.002	0.03	tr	tr	0.03	tr	tr	tr	tr	0.003	

[0084]
[A table 12]

α	スラブ→熱延（インライン焼入れ焼戻し）→スリット→造管
β	スラブ→熱延→連続焼鈍（インライン焼入れ焼戻し）→スリット→造管
γ	スラブ→熱延→冷延→連続焼鈍（インライン焼入れ焼戻し）→スリット→造管
δ	スラブ→熱延→スリット→造管→焼入れ焼戻し
ε	スラブ→熱延→冷延→焼鈍→スリット→造管→焼入れ焼戻し

[0085]
[A table 13]

番号	鋼	製造方法	マルテンサイト分率 (%)	浸漬試験前のTS (N/mm²)	浸漬試験後のTS (N/mm²)	残留強度率 (%)	
1	M	α	80	1220	1040	85	発明例
2	M	γ	100	1420	1180	83	
3	M	δ	100	1400	1200	86	
4	N	α	80	1410	1300	92	
5	N	γ	100	1230	1110	90	
6	N	δ	100	1380	1210	88	
7	O	α	100	1530	1250	82	
8	O	γ	100	1520	1260	83	
9	O	δ	100	1470	1180	80	
10	O	ε	100	1550	1280	81	
11	P	α	100	1450	1190	82	
12	P	β	100	1520	1260	83	
13	P	γ	100	1550	1240	80	
14	P	δ	100	1540	1260	82	
15	Q	α	100	1560	1260	81	
16	Q	δ	100	1530	1250	82	
17	R	α	100	1380	990	72	比較例
18	R	β	100	1420	1040	73	
19	R	γ	100	1500	1110	74	
20	R	δ	100	1510	1120	74	
21	R	ε	100	1500	1080	72	
22	S	α	80	1320	920	70	
23	S	γ	100	1570	—	遅れ破壊割れ	
24	S	δ	100	1550	1010	65	

[0086] For the electroseamed steel pipe of the example of invention which fulfills the conditions specified by this invention in the steel presentation and the organization so that clearly from a table 13, tensile strength is 2 1180Ns/mm. It was above, and the rate of retained strength was high, and having the outstanding endurance was checked.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the relation between Cu addition and crack generating marginal addition distortion variation.
[Drawing 2] Drawing showing the relation between nickel addition and crack generating marginal addition distortion variation.
[Drawing 3] Q/2 (t/D) Drawing showing relation with hydrogen delay crack generating marginal addition distortion.
[Drawing 4] The holding time and hydrogen delay crack generating marginal addition distortion deltaepsilonc in a 150-250-degree C temperature requirement Drawing showing relation.
[Drawing 5] Drawing showing the relation between Cu addition and the rate of retained strength after a corrosion test.
[Drawing 6] Drawing showing the relation between nickel addition and the rate of retained strength after a corrosion test.
[Drawing 7] Drawing showing the relation between Mo addition and the rate of retained strength after a corrosion test.

[Translation done.]

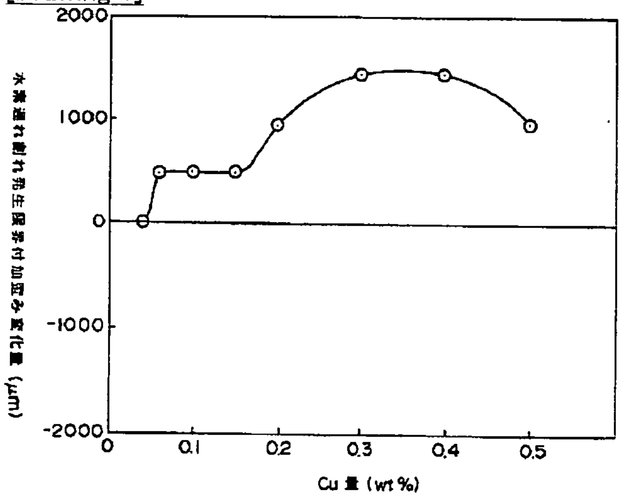
* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

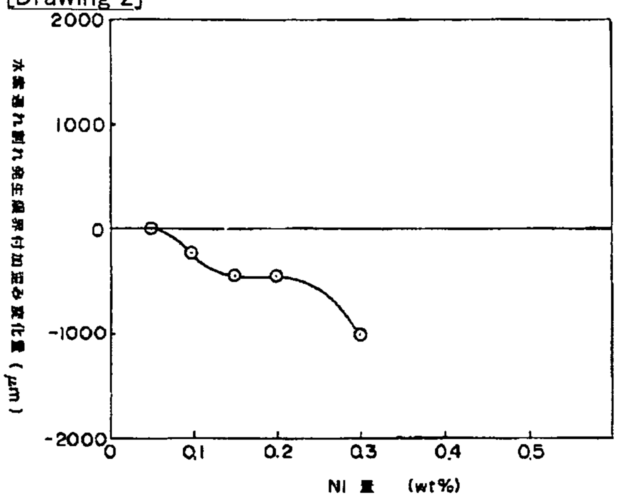
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

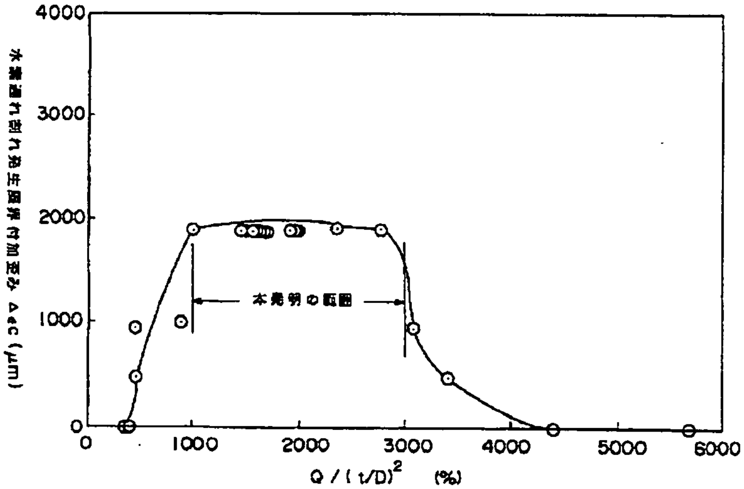
[Drawing 1]



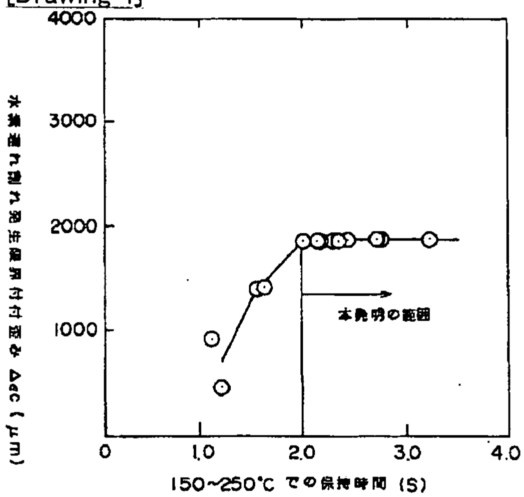
[Drawing 2]



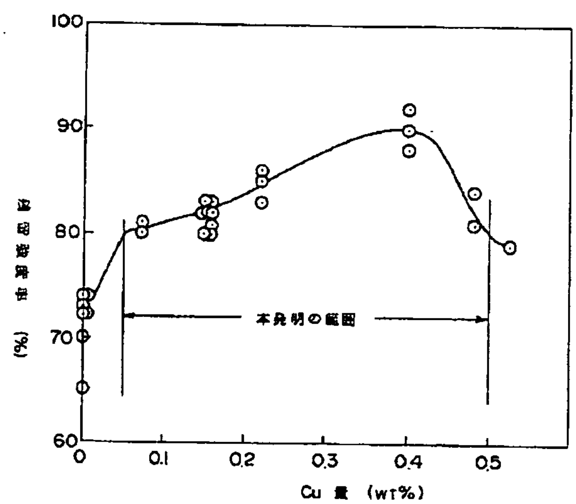
[Drawing 3]



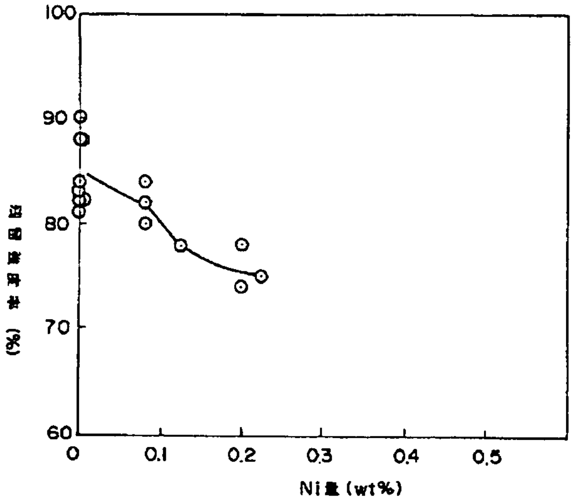
[Drawing 4]



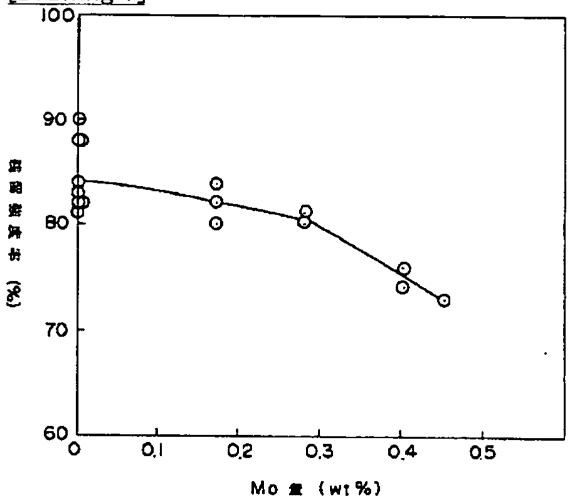
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Translation done.]